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(54) Title: ANTIBODIES AGAINST THE ADVANCED GLYCOSYLATION END-PRODUCT RECEPTOR AND USES THEREOF

## (57) Abstract

It is a general object of the present invention to provide compositions that specifically interact with advanced glycosylation end products (AGEs) or their receptors. Such compositions may be used in a variety of applications including therapeutic applications, e.g., as blocking agents to inhibit or otherwise reduce the AGE/RAGE interaction, screening applications, e.g., as models of the AGE/RAGE interaction, and diagnostic applications, e.g., to identify abnormal levels of AGE or RAGE in a given system.

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## ANTIBODIES AGAINST THE ADVANCED GLYCOSYLATION END-PRODUCT RECEPTOR AND USES THEREOF

## BACKGROUND OF THE INVENTION

5           Advanced glycosylation end-products of proteins (AGEs) have been implicated in a variety of disorders including complications associated with diabetes and normal aging. AGEs are nonenzymatically glycosylated proteins which have been shown to accumulate in vascular tissue in aging and at an accelerated rate in individuals with diabetes. Particularly, AGEs result from the non-enzymatic, but  
10           concentration dependant interaction of glucose and other reducing sugars with amino groups on proteins to form glycosylated proteins termed Amadori adducts. Over time, these Amadori adducts undergo additional rearrangements, dehydrations and cross-linking with other proteins to accumulate as a family of complex structures referred to as AGEs.

15           AGEs have been shown to bind specifically in a saturable and reversible manner to cell surface receptors, including receptors expressed on the surface of endothelial cells and particularly those of the microvasculature, monocytes/macrophages, smooth muscle cells, mesengial cells and neurons.

          Following binding to cell surface receptors, AGEs are taken up in  
20           vesicles and either degraded intracellularly or transported through the cells and deposited in the sub-endothelial matrix, where they accumulate. Esposito et al., J. Exp. Med. 170:1387-1407 (1989). In addition, chemotactic signals for monocytes, but not other white cells are released. These monocytes then adhere and diapedese through the endothelial cell layer. Kirstein et al., Proc. Nat'l Acad. Sci.  
25           USA 187:9010-9014 (1990).

          AGEs also have been shown to cause proliferation of endothelial cells, which become more permeable and more thrombogenic, i.e., thrombomodulin is downregulated while tissue factor is upregulated. Esposito et al., J. Exp. Med. 170:1387-1407 (1989).

30           Monocytes\macrophages can also take up AGEs through their receptors which are distinct from the acetyl-LDL receptors, but which may be related to the receptors for aldehyde-modified proteins. Takata et al., J. Biol. Chem. 263:14819-14825 (1988), Takata et al., Biochim. Biophys. Acta 986:18-26 (1989), Radoff et al., Diabetes 39:1510-1518 (1990). Binding of AGEs to monocytes in vitro  
35           leads to the induction of cytokines, TNF and IL-1, which then stimulate the release of a number of other growth factors responsible for cell proliferation, migration and matrix synthesis. Vlassara et al., Science 240:1546-1548 (1988). Increased synthesis of matrix proteins in response to AGEs binding has also been

demonstrated for mesangial cells. Skolnick et al., J. Exp. Med. 174:931-939 (1991), Doi et al., Proc. Nat'l Acad. Sci. USA 89:2873-2877 (1992).

Evidence has indicated that the binding of AGEs to their receptors either directly or indirectly induces inflammatory responses in vessel walls, which  
5 can trigger or aggravate the pathogenesis of diabetic macro- or microangiopathy. For an overview of the effects of AGEs, see, e.g., Vlassara et al., Laboratory Invest. 70(2):138-151 (1994). Stern et al., J. Biol. Chem. 267:14998-15004 (1992) has reported similarities between RAGE proteins and the Ig superfamily molecules.

Because of the effects AGEs may have in the pathogenesis of a  
10 number of disorders, it would generally be desirable to provide compositions and methods to block or otherwise inhibit these effects, and particularly the interaction between AGEs and their cell surface receptors. The present invention meets these and a variety of other needs.

15

#### SUMMARY OF THE INVENTION

It is a general object of the present invention to provide novel  
polypeptides and antibodies, as well as methods of using these polypeptides and  
20 antibodies in screening, diagnostic and therapeutic applications.

In a first aspect, the present invention provides isolated antibodies that are specifically immunoreactive with a soluble human RAGE polypeptide. In particular, the antibodies of the invention will be specifically immunoreactive with a polypeptide having an amino acid sequence substantially homologous to the amino  
25 acid sequence shown in Figure 1 (Seq ID NOS: 2 and 4), or immunologically active fragments thereof. The present invention also provides pharmaceutical compositions which include these antibodies.

The antibodies of the present invention may also be used in therapeutic applications. For example, in a further aspect, the present invention  
30 provides methods of treating a patient for symptoms of a disorder which are caused by an interaction between an AGE and its receptor. The methods comprise administering an effective amount of an antibody that is specifically immunoreactive with a soluble human RAGE polypeptide to the patient.

In an additional aspect, the antibodies of the present invention may be  
35 used as affinity probes. For example in an additional aspect, the antibodies of the invention may be used in methods for detecting a human RAGE polypeptide in a sample. The methods comprise contacting the sample with an isolated antibody that is specifically immunoreactive with a soluble human RAGE polypeptide, and

determining whether the antibody specifically immunoreacts with a component of the sample.

In a related aspect, the invention provides methods of purifying human RAGE polypeptides from a mixture of proteins. For these methods, an antibody  
5 that is specifically immunoreactive with a soluble human RAGE polypeptide is immobilized on a solid support. The solid support is contacted with the mixture of proteins under conditions which will permit specific immunoreaction between the antibody and the human RAGE polypeptide. The solid support is washed to  
10 remove nonspecifically bound proteins and the RAGE polypeptide is eluted from the solid support in substantially pure form.

Further, the present invention provides the use of an effective amount of an antibody that is specifically immunoreactive with a soluble human RAGE polypeptide for the production of a pharmaceutical pomound or composition for the  
15 treatment of a patient for symptoms of a disorder, wherein said symptoms are caused by an interaction between an AGE and its receptor.

Especially, said patients are diabetic patients, and said symptom is increased vascular permeability. Especially, said disorder is Diabetes Mellitus and said  
20 symptom is selected from the group consisting of diabetic microvasculopathy, diabetic macrovasculopathy and occlusive vascular disorder.

Especially, said symptoms are selected from the group consisting of neuropathy, nephropathy, retinopathy and atherosclerosis.

Especially, said symptom is hemodialysis-associated amyloidosis.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A and 1B show the nucleic acid sequence and deduced amino acid sequence of a soluble human RAGE polypeptide (Seq ID NOS: 1-4). Figure 1A shows the DNA and amino acid sequence of soluble human RAGE which includes an expressed pre-sequence (Seq ID NOS: 1-2), whereas Figure 1B shows the sequences for mature soluble human RAGE (Seq ID NOS: 3-4). Standard three-letter abbreviations are used to denote the individual amino acids.

Figures 2A and 2B show binding of an AGE-BSA protein to indirectly immobilized RAGE polypeptide. Figure 2A shows total binding of labeled AGE-BSA to RAGE immobilized indirectly upon a solid support through a FLAG peptide/antiFLAG antibody interaction which mimics the cell surface presentation of RAGE (squares). Also shown is nonspecific binding (diamonds)(labeled AGE-BSA binding in the presence of excess unlabeled AGE-BSA). Figure 2B shows corrected, specific binding of AGE-BSA to RAGE polypeptide that is indirectly coupled to the solid support.

Figure 3 shows a dose response curve for RAGE/AGE binding in the presence of increasing concentrations of free RAGE

Figure 4A is a bar graph showing levels of antibody binding to human soluble RAGE using an EIA antibody capture assay. Binding is compared between intact soluble RAGE (dark bars) and RAGE/DCC chimeric protein (in which the first Ig-like domain of RAGE is replaced with the first Ig-like domain of DCC, a member of the Ig superfamily. Four antibodies (#5, 9, 14 and 19) recognized both the intact soluble RAGE and the chimeric protein. Figures 4B and 4C show antibody binding to peptide fragments of soluble human RAGE, designated peptide 1 (CKGAPKKPPQ) (Seq ID NO: 5), fragment 2 (WKLNTGRTEAC) (Seq ID NO: 6) and fragment 8 (GPQDQGTYSYSC) (Seq ID NO: 7).

Figure 5 shows a Western Blot hybridization of anti-RAGE MAb SW1E8 (ATCC Accession No. HB-12166). Lanes 1-3 represent rat, mouse and human RAGE expressed in Baculovirus, respectively. Lanes were loaded with 5  $\mu$ l of conditioned media. Monomeric RAGE is apparent as a doublet at approximately 41 Kd.

Figures 6A and 6B show results of a direct antigen capture EIA. Figure 6A shows a capture assay employing MAb RBF9D9 (ATCC Accession No. HB-12165) as the RAGE capture antibody and MAb SW10C1 (ATCC Accession No. HB-12164) as the RAGE detection antibody, which recognizes human, but not murine RAGE. Figure 6B shows a capture assay employing MAb RBF9D9 (ATCC Accession No. HB-12165) as the RAGE capture antibody and MAb SW1E8 (ATCC

Accession No. HB-12166) as the detection antibody, which recognizes both human and murine RAGE.

Figure 7 shows the results of flow cytometry of CHO parental cells and CHO cells transfected with full length human RAGE, using anti-RAGE MAb SW10C1 (ATCC Accession No. HB-12164). Sixty nine of the original 72 MAb panel demonstrated similar reactivity with cell surface RAGE.

Figures 8A and 8B show results of flow cytometry of CHO parental and CHO-RAGE transfectants incubated with lactoferrin and immunostained with anti-RAGE/phycoerythrin (Figure 8A) and anti-lactoferrin/FITC (Figure 8B).

Figures 9A and 9B show the in vitro permeability of confluent BEAC layers by albumin and inulin. Permeability is shown following incubation with medium (control, white bar), normal RBCs (black bar) and diabetic RBCs (hatched bars). Reversal of diabetic RBC associated permeability is demonstrated following pretreatment with soluble recombinant RAGE (sRAGE) but not control protein (sVCAM).

Figure 10 shows plasma pharmacokinetics of  $^{125}\text{I}$ -human recombinant RAGE after an intravenous infusion into rat.

Figures 11A and 11B show comparisons of efficiency of recombinant soluble human RAGE and recombinant rat-VCAM in reversing permeability induced by diabetic RBC incubation in various tissues of normal (Figure 11A) and diabetic rats (Figure 11B).

Figure 12 shows a schematic illustration of the blood-tissue albumin transport tracer uptake method. Also shown are the calculations used to obtain albumin clearance values.

Figures 13A, 13B and 13C show albumin clearance from various tissues in control rats (white bar), diabetic rats (left black bar), diabetic rats with soluble RAGE pretreatment (middle black bar) and diabetic rats with soluble VCAM-1 pretreatment (right black bar) in early (Figure 13A), mid (Figure 13B) and late (Figure 13C) phases of STZ-induced diabetes.

Figures 14A, 14B and 14C show extravascular water levels from various tissues in control rats (white bar), diabetic rats (left black bar), diabetic rats with soluble RAGE pretreatment (middle black bar) and diabetic rats with soluble VCAM-1 pretreatment (right black bar) in early (Figure 14A), mid (Figure 14B) and late (Figure 14C) phases of diabetes.

Figures 15A and 15B show adhesion of RAGE pretreated and control RBCs to single vessels.

## DETAILED DESCRIPTION OF THE INVENTION

I. General

The major pathological conditions in which AGEs have been implicated as exerting adverse effects include Diabetes Mellitus in which hyperglycemia exists, as well as a number of aging related disorders. AGE formation in biological systems is dependant upon blood-glucose concentration and time of incubation. Without being bound to a particular theory, it is believed that this time/concentration dependency accounts for the adverse effects in hyperglycemic diabetics as well as the elderly. Similarly, proteins which themselves have a longer half-life, are more prone to undergo glycosylation to form AGEs. In diabetic patients, a high level of plasma glucose leads to glycosylation of various plasma proteins, including hemoglobin and LDL (low-density lipoprotein) as well as enzymes and matrix proteins. The accumulation of these AGEs induce a number of permanent abnormalities in the extracellular matrix component function, and stimulate cytokines and reactive oxygen species production through AGE-specific receptors. Inhibition of AGE formation in long term diabetic animals has also been shown to prevent or reduce the severity of a number of elements of the pathology of diabetes, including retinopathy, nephropathy, neuropathy and arterial abnormalities. Brownlee, Ann. Rev. Med. 46:223-234 (1995), Zimmerman et al., Proc. Nat'l Acad. Sci. USA 92:3744-3748 (1995).

A number of proteins associated with Alzheimer's disease, e.g., amyloid, tau, the major components of neurofibrillary tangles and senile plaques, are found to be similarly modified. Smith et al., Nature 374:316 (1995), Smith et al., Proc. Nat'l Acad. Sci. USA, 91:5710-5714 (1994), Vitek et al., Proc. Nat'l Acad. Sci. USA, 91:4766-4770 (1994). Additionally, in hemodialysis-associated amyloidosis,  $\beta_2$ -microglobulin, a major component of amyloid fibrils, is modified by glycosylation. Miyata et al., J. Clin. Invest. 93:521-528 (1994). In atherosclerosis, in both the diabetic and non-diabetic populations, LDL, Lp(a)(lipoprotein little a) and immunoglobulin that are trapped and/or cross-linked to the matrix within the vessel wall are modified by glycosylation. The presence of AGEs produces a local, chronic inflammation, through a number of mechanisms including receptor-mediated pathway and oxidant stress. As a result, it is apparent that AGE modification causes and/or aggravates these various pathological conditions.

Because of these effects of AGEs in the pathogenesis of various disorders, it is a general object of the present invention to provide compositions that specifically interact with advanced glycosylation end products (AGEs) or their receptors. Such compositions may be used in a variety of applications including therapeutic applications, e.g., as blocking agents to inhibit or otherwise reduce the AGE/RAGE interaction, screening applications, e.g., as models of the AGE/RAGE



interaction, and diagnostic applications, e.g., to identify abnormal levels of AGE or RAGE in a given system.

In preferred aspects, the present invention provides compositions comprising soluble RAGE polypeptides, antibodies that are specifically immunoreactive with soluble RAGE polypeptides, and methods of using these compositions in screening, therapeutic and diagnostic applications.

## II. Polypeptides

10

In a first aspect, the present invention provides substantially pure or isolated polypeptides that are related to and/or derived from human RAGE polypeptides. The terms "substantially pure" or "isolated", when referring to proteins and polypeptides, denote those polypeptides that are separated from proteins or other contaminants with which they are naturally associated. A protein or polypeptide is considered substantially pure when that protein makes up greater than about 50% of the total protein content of the composition containing that protein, and typically, greater than about 60% of the total protein content. More typically, a substantially pure or isolated protein or polypeptide will make up from about 75 to about 90% of the total protein. Preferably, the protein will make up greater than about 90%, and more preferably, greater than about 95% of the total protein in the composition.

In particular aspects, the isolated polypeptides of the present invention are related to and/or derived from soluble human RAGE polypeptides. As used herein, the term "soluble" generally refers to RAGE derived polypeptides that lack a transmembrane region that is associated with full length RAGE polypeptides. Thus, soluble RAGE polypeptides generally comprise fragments of the extracellular domain of RAGE. In certain embodiments, the soluble peptides of the invention will comprise one or more of the Ig-like domains of the extracellular region of RAGE.

As used herein, "AGE" refers to an advanced glycosylation end-product. Typically, such AGEs may be full length proteins, polypeptides or aggregations of proteins and/or polypeptides.

The polypeptides of the invention also may be characterized by their ability to either mimic or inhibit the interaction between AGEs and their receptors, e.g., RAGE. Those polypeptides which are mimetic of either AGE or its receptors in the AGE/receptor interaction are termed AGE or AGE receptor "mimics".

In particularly preferred aspects, the polypeptides of the invention will have an amino acid sequence that is related to or derived from the amino acid sequence of soluble human RAGE as shown in Figures 1A and 1B (Seq ID NOS: 2

and 4). Although described in terms of the amino acid sequence shown in Figure 1A and 1B (Seq ID NOS: 2 and 4), it will be readily understood that the polypeptides of the present invention include those peptides having the listed amino acid sequence or biologically active fragments thereof, as well as those polypeptides having amino acid sequences that are substantially homologous to the listed sequence.

The terms "substantially homologous" when referring to polypeptides, refer comparatively to two amino acid sequences which, when optimally aligned, are at least about 75% homologous, preferably at least about 85% homologous more preferably at least about 90% homologous, and still more preferably at least about 95% homologous. Optimal alignment of sequences for aligning a comparison window may be conducted by the local homology algorithm of Smith and Waterman (1981) Adv. Appl. Math. 2:482, by the homology alignment algorithm of Needleman and Wunsch (1970) J. Mol. Biol. 48:443, by the search for similarity method of Pearson and Lipman (1988) Proc. Natl. Acad. Sci. (USA) 85:2444, or by computerized implementations of these algorithms (GAP, BESTFIT, FASTA, and TFASTA in the Wisconsin Genetics Software Package Release 7.0, Genetics Computer Group, 575 Science Dr., Madison, WI).

The term "biologically active fragment" as used herein, refers to portions of the soluble RAGE polypeptides, which possess a particular biological activity. For example, such biological activity may include the ability to bind a particular protein, substrate or ligand, e.g., AGE, to have antibodies generated against it, to block or otherwise inhibit an interaction between two proteins, e.g., a receptor and its ligand, such as AGE and RAGE, between an enzyme and its substrate, between an epitope and an antibody, or such fragments may include a particular catalytic activity. With regard to the polypeptides of the present invention, particularly preferred polypeptides or biologically active fragments include, e.g., polypeptides that possess one or more of the biological activities described above, such as the ability to specifically interact with AGEs, the ability to block, reduce, or otherwise inhibit the interaction between AGEs and RAGE, and the ability to elicit antibodies that are specifically immunoreactive with AGEs or RAGE. Those fragments that are specifically recognized and bound by antibodies raised against the polypeptides of the invention are also included in the definition of biologically active fragments. Such fragments are also referred to herein as "immunologically active fragments." Examples of immunologically active fragments include those fragments comprising the amino acid sequences specifically described below, and particularly those selected from the group consisting of: WKLNTGRTEA (Seq ID NO: 8), CEVPAQPSPQI (Seq ID NO: 9), CRAMNQNGKETKSN (Seq ID NO: 10), GPQDQGTYSYSC (Seq ID NO: 11), AQNITARIGEPLVLK (Seq ID NO: 12),

CKGAPKKPPQ (Seq ID NO: 13), EQTRRHPE (Seq ID NO: 14), RGGDPRPTFSC (Seq ID NO: 15), SPGLPRHRAL (Seq ID NO: 16), and SSHGPQESRA (Seq ID NO: 17).

As described previously, the polypeptides of the invention may further include modifications to the N- or C-termini, i.e., acetylation, amidation, or inclusion of additional amino acids to assist in conjugation with other proteins or other compounds, e.g., polypeptides having the following sequences: WKLNTGRTEAC (Seq ID NO: 6); AQNITARIGEPLVLKC (Seq ID NO: 18); CEQTRRHPE (Seq ID NO: 19); CSPGLPRHRAL (Seq ID NO: 20); and SSHGPQESRAC (Seq ID NO: 21).

The polypeptides of the invention may also be characterized by their ability to block the interaction between two proteins, e.g. AGE and RAGE, RAGE and anti-RAGE Abs, or AGE and anti-AGE Abs. In particular, included in the polypeptides of the present invention are peptides derived from human RAGE proteins that are capable of blocking or otherwise inhibiting the interaction between human RAGE and its ligands and particularly, AGEs. Examples of such polypeptides include fragments of human RAGE which encompass the AGE binding regions of the RAGE protein as well as AGE-binding proteins that sterically interfere with RAGE/AGE binding.

As referenced above, the polypeptides of the present invention may also be characterized by their ability to bind antibodies raised against proteins or polypeptides having the amino acid sequences of soluble human RAGE, as shown in Figure 1A and 1B (Seq ID NOS: 2 and 4), or fragments thereof. These antibodies generally recognize polypeptides that are homologous to at least portions of human RAGE proteins or their immunologically active fragments. A variety of immunoassay formats may be used to select antibodies specifically immunoreactive with a particular protein or domain. For example, solid-phase ELISA immunoassays are routinely used to select monoclonal antibodies specifically immunoreactive with a protein. See Harlow and Lane (1988) Antibodies, A Laboratory Manual, Cold Spring Harbor Publications, New York, for a description of immunoassay formats and conditions that can be used to determine specific immunoreactivity. Antibodies to the polypeptides of the present invention are discussed in greater detail, below.

Generally, the biologically active fragments of the polypeptides described herein may include any subsequence of the above described RAGE polypeptide. Typically, however, such biologically active fragments will range in size from about 10 amino acids in length to about 320 amino acids in length. More typically, the biologically active fragments will be from about 10, 11, 12, 13, 14, 15 or 16 amino acids in length to about 50 amino acids in length.

Examples of particularly preferred biologically active fragments of soluble human RAGE include peptides comprising an amino acid sequence selected from the group consisting of WKLNTGRTEA (Seq ID NO: 8), CEVPAQPSPQI (Seq ID NO: 9), CRAMNQNGKETKSN (Seq ID NO: 10),  
5 GPQDQGTYSYSC (Seq ID NO: 11), AQNITARIGEPLVLK (Seq ID NO: 12), CKGAPKKPPQ (Seq ID NO: 13), EQTRRHPET (Seq ID NO: 14), RGGDPRPTFSC (Seq ID NO: 15), SPGLPRHRAL (Seq ID NO: 16), and SSHGPQESRA (Seq ID NO: 17).

The polypeptides of the present invention may generally be prepared  
10 using recombinant or synthetic methods that are well known in the art. Recombinant techniques are generally described in Sambrook, et al., Molecular Cloning: A Laboratory Manual, (2nd ed.) Vols. 1-3, Cold Spring Harbor Laboratory, (1989). The term recombinant is also intended to encompass the recombinant expression of heterologous genetic material which is introduced into a host cell or  
15 transfectant through viral transfection techniques. Techniques for the synthesis of polypeptides are generally described in Merrifield, J. Amer. Chem. Soc. 85:2149-2456 (1963), Atherton, et al., Solid Phase Peptide Synthesis: A Practical Approach, IRL Press (1989), and Merrifield, Science 232:341-347 (1986). In preferred aspects, the polypeptides of the present invention may be expressed by a suitable  
20 host cell that has been transfected with a nucleic acid of the invention, as described in greater detail below.

Biologically active fragments of the above described polypeptides may generally be identified and prepared using methods well known in the art. For example, selective proteolytic digestion, recombinant deletional methods or *de novo*  
25 peptide synthesis methods may be employed to identify portions of the above described peptides that possess the desired biological activity, e.g., AGE binding, presence of immunological determinants, and the like. See, e.g., Sambrook, et al.

Isolation and purification of the polypeptides of the present invention can be carried out by methods that are generally well known in the art. For  
30 example, the polypeptides may be purified using readily available chromatographic methods, e.g., ion exchange, hydrophobic interaction, HPLC or affinity chromatography, to achieve the desired purity. Affinity chromatography may be particularly attractive in allowing an individual to take advantage of the specific biological activity of the desired peptide, e.g., AGE binding, presence of antigenic  
35 determinants or the like. For example, antibodies raised against human RAGE polypeptides or its immunologically active fragments, may be coupled to a suitable solid support and contacted with a mixture of proteins containing the polypeptides of the invention under conditions conducive to the association of these polypeptides with the antibody. Once bound to the immobilized antibody, the solid support is

washed to remove unbound material and/or nonspecifically bound proteins. The desired polypeptides may then be eluted from the solid support in substantially pure form by, e.g., a change in salt, pH or buffer concentration. Alternatively, the affinity of the soluble RAGE polypeptides for AGEs may be used advantageously to purify these peptides. In particular, AGEs, e.g. BSA-AGE, may be immobilized as described above, for use as affinity probes in the purification of the soluble RAGE polypeptides.

In addition to those polypeptides and fragments described above, the present invention also provides fusion proteins which contain these polypeptides or fragments. Fusion proteins may be useful in providing for enhanced expression of the RAGE polypeptide constructs, or in producing RAGE polypeptides having other desirable properties, e.g., labeling groups, e.g., enzymatic reporter groups, binding groups, antibody epitopes, etc.

The term "fusion protein" as used herein, generally refers to a composite protein, i.e., a single contiguous amino acid sequence, made up of two distinct, heterologous polypeptides which are not normally fused together in a single amino acid sequence. Thus, a fusion protein may include a single amino acid sequence that contains two entirely distinct amino acid sequences or two similar or identical polypeptide sequences, provided that these sequences are not normally found together in a single amino acid sequence. Fusion proteins may generally be prepared using either recombinant nucleic acid methods, i.e., as a result of transcription and translation of a gene fusion, which fusion comprises a segment encoding a polypeptide of the invention and a segment encoding a heterologous protein, or by chemical synthesis methods well known in the art.

Also included within the present invention are amino acid variants of the above described polypeptides. These variants may include insertions, deletions and substitutions with other amino acids. For example, in some aspects, conservative amino acid substitutions may be made, i.e., substitution of selected amino acids with different amino acids having similar structural characteristics, e.g., net charge, hydrophobicity and the like. Examples of such conservative substitutions include, e.g., Ala:Val:Leu:Ile:Met, Asp:Glu, Lys:Arg, Asn:Gln, Phe:Tyr and Ser:Thr. Glycosylation modifications, either changed, increased amounts or decreased amounts, as well as other sequence modifications are also included within the polypeptides of the invention.

Systematic substitution of one or more amino acids of a consensus sequence with a D-amino acid of the same type (e.g., D-lysine in place of L-lysine) may also be used to generate more stable peptides. In addition, constrained peptides comprising a consensus sequence or a substantially identical consensus sequence variation may be generated by methods known in the art (Rizo and

Gierasch (1992) Ann. Rev. Biochem. 61:387; for example, by adding internal cysteine residues capable of forming intramolecular disulfide bridges which cyclize the peptide. Similarly, modification of the amino or carboxy terminals may also be used to confer stabilizing properties upon the polypeptides of the invention, e.g.,  
5 amidation of the carboxy-terminus or acylation of the amino-terminus. Substitution of amino acids involved in catalytic activity can be used to generate dominant negative inhibitors of signaling pathways.

Furthermore, although primarily described in terms of "proteins" or "polypeptides" one of skill in the art, upon reading the instant specification, will  
10 appreciate that these terms also include structural analogs and derivatives of the above-described polypeptides, e.g., polypeptides having conservative amino acid insertions, deletions or substitutions, peptidomimetics, and the like. For example, in addition to the above described polypeptides which consist only of naturally-occurring amino acids, peptidomimetics of the polypeptides of the present invention  
15 are also provided. Peptide analogs are commonly used in the pharmaceutical industry as non-peptide drugs with properties analogous to those of the template peptide. These types of non-peptide compounds are termed "peptide mimetics" or "peptidomimetics" (Fauchere, J. (1986) Adv. Drug Res. 15:29; Veber and Freidinger (1985) TINS p.392; and Evans et al. (1987) J. Med. Chem. 30:1229, and  
20 are usually developed with the aid of computerized molecular modeling. Peptide mimetics that are structurally similar to therapeutically useful peptides may be used to produce an equivalent therapeutic effect. Generally, peptidomimetics are structurally similar to a paradigm polypeptide (*i.e.*, a polypeptide that has a biological or pharmacological activity), such as naturally-occurring receptor  
25 polypeptides, but have one or more peptide linkages optionally replaced by a linkage selected from the group consisting of:  $-CH_2NH-$ ,  $-CH_2S-$ ,  $-CH_2-CH_2-$ ,  $-CH=CH-$  (cis and trans),  $-COCH_2-$ ,  $-CH(OH)CH_2-$ , and  $-CH_2SO-$ , by methods known in the art and further described in the following references: Spatola, A.F. in Chemistry and Biochemistry of Amino Acids, Peptides, and Proteins, B. Weinstein, eds., Marcel Dekker, New York, p. 267 (1983); Spatola, A.F., Vega Data (March  
30 1983), Vol. 1, Issue 3, "Peptide Backbone Modifications" (general review); Morley, J.S., Trends Pharm. Sci. (1980) pp. 463-468 (general review); Hudson, D. et al., Int. J. Pept. Prot. Res. (1979) 14:177-185 ( $-CH_2NH-$ ,  $-CH_2CH_2-$ ); Spatola, A.F. et al., Life Sci (1986) 38:1243-1249 ( $-CH_2S-$ ); Hann, M.M., J. Chem. Soc. Perkin Trans. I  
35 (1982) 307-314 ( $-CH=CH-$ , cis and trans); Almquist, R.G. et al., J. Med. Chem. (1980) 23:1392-1398 ( $-COCH_2-$ ); Jennings-White, C. et al., Tetrahedron Lett. (1982) 23:2533 ( $-COCH_2-$ ); Szelke, M. et al., European Appln. EP 45665 (1982) CA: 97:39405 (1982) ( $-CH(OH)CH_2-$ ); Holladay, M.W. et al., Tetrahedron Lett. (1983) 24:4401-4404 ( $-C(OH)CH_2-$ ); and Hruby, V.J., Life Sci. (1982) 31:189-199 ( $-CH_2S-$ ).

Peptide mimetics may have significant advantages over polypeptide embodiments, including, for example: more economical production; greater chemical stability; enhanced pharmacological properties (half-life, absorption, potency, efficacy, etc.); altered specificity (e.g., a broad-spectrum of biological activities); reduced antigenicity; and others.

For many applications, it will also be desirable to provide the polypeptides of the invention as labeled entities, i.e., covalently attached or linked to a detectable group, to facilitate identification, detection and quantification of the polypeptide in a given circumstance. These detectable groups may comprise a detectable protein group, e.g., an assayable enzyme or antibody epitope as described above in the discussion of fusion proteins. Alternatively, the detectable group may be selected from a variety of other detectable groups or labels, such as radiolabels (e.g.,  $^{125}\text{I}$ ,  $^{32}\text{P}$  or  $^{35}\text{S}$ ) or a chemiluminescent or fluorescent group. Similarly, the detectable group may be a substrate, cofactor, inhibitor or affinity ligand. Labeling of peptidomimetics usually involves covalent attachment of one or more labels, directly or through a spacer (e.g., an amide group), to non-interfering position(s) on the peptidomimetic that are predicted by quantitative structure-activity data and/or molecular modeling. Such non-interfering positions generally are positions that do not form direct contacts with the molecules to which the peptidomimetic binds (e.g., AGE) to produce the therapeutic effect. Derivatization (e.g., labeling) of peptidomimetics should not substantially interfere with the desired biological or pharmacological activity of the peptidomimetic. Generally, peptidomimetics of peptides of the invention bind to their ligands (e.g., AGEs) with high affinity and/or possess detectable biological activity (i.e., are agonistic or antagonistic to AGE/RAGE interaction and phenotypic changes brought about by those interactions).

### III. Antibodies to RAGE

In an additional aspect, the present invention provides antibodies that are specifically immunoreactive with human RAGE and more particularly, the soluble human RAGE polypeptides of the invention. The phrase "specifically immunoreactive," when referring to the interaction between an antibody of the invention and a particular protein, refers to an antibody that specifically recognizes and binds with relatively high affinity to the protein of interest, e.g., RAGE, such that this binding is determinative of the presence of the protein in a heterogeneous population of proteins and other biologics. Thus, under designated immunoassay conditions, the specified antibodies bind to a particular protein and do not bind in a significant amount to other proteins present in the sample. A variety of

immunoassay formats may be used to select antibodies specifically immunoreactive with a particular protein. For example, solid-phase ELISA immunoassays are routinely used to select monoclonal antibodies specifically immunoreactive with a protein. See, Harlow and Lane (1988) *Antibodies, A Laboratory Manual*, Cold Spring Harbor Publications, New York, for a description of immunoassay formats and conditions that can be used to determine specific immunoreactivity.

For production of polyclonal antibodies, an appropriate target immune system is selected, typically a mouse or rabbit, but also including goats, sheep, cows, guinea pigs, monkeys and rats. The substantially purified antigen is presented to the immune system in a fashion determined by methods appropriate for the animal. These and other parameters are well known to immunologists. Typically, injections are given in the footpads, intramuscularly, intradermally or intraperitoneally. The immunoglobulins produced by the host can be precipitated, isolated and purified by routine methods, including affinity purification.

For monoclonal antibodies, appropriate animals will be selected and the desired immunization protocol followed. After the appropriate period of time, the spleens of these animals are excised and individual spleen cells are fused, typically, to immortalized myeloma cells under appropriate selection conditions. Thereafter, the cells are clonally separated and the supernatants of each clone are tested for the production of an appropriate antibody specific for the desired region of the antigen. Techniques for producing antibodies are well known in the art. See, e.g., Goding et al., *Monoclonal Antibodies: Principles and Practice* (2d ed.) Acad. Press, N.Y., and Harlow and Lane, *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory, New York (1988). Other suitable techniques involve the *in vitro* exposure of lymphocytes to the antigenic polypeptides or alternatively, to selection of libraries of antibodies in phage or similar vectors. Huse et al., *Generation of Large Combinatorial Library of the Immunoglobulin Repertoire in Phage Lambda*, *Science* 246:1275-1281 (1989). Monoclonal antibodies with affinities of  $10^8$  liters/mole, preferably  $10^9$  to  $10^{10}$  or stronger, will be produced by these methods.

The antibodies generated can be used for a number of purposes, e.g., as probes in immunoassays, for inhibiting interaction between AGEs and their receptors, in diagnostic or therapeutic applications. These applications are discussed in greater detail, below. Where the antibodies are used to block the interaction between AGEs and their receptors, the antibody will generally be referred to as a "blocking antibody."

The antibodies of the present invention can be used with or without modification. Frequently, the antibodies will be labeled by joining, either covalently or non-covalently, a substance which provides for a detectable signal. Such labels include those that are well known in the art, such as the labels described previously



for the polypeptides of the invention, e.g., radioactive, fluorescent or bioactive labels. As labeled binding entities, the antibodies of the invention may be particularly useful in, e.g., diagnostic applications, for identifying abnormal levels of RAGE in human tissue or blood samples which abnormal levels may be indicative of the existence of or enhanced potential for those disorders associated with excessive RAGE/AGE interaction, as described herein.

In alternative aspects, the antibodies of the present invention may be used as affinity ligands in the quantitation and/or purification of the RAGE polypeptides from a mixture of proteins. These antibody affinity purification methods are well known in the art, and typically involve the immobilization of a particular antibody, e.g., an antibody to soluble human RAGE, upon a solid support. Solid supports for use in affinity chromatography are generally commercially available from, e.g., Sigma Chemical Co. (St Louis MO) and Pharmacia (Uppsala, Sweden).

Additionally, the antibodies of the invention may be chimeric, human-like or humanized, in order to reduce their potential antigenicity, without reducing their affinity for their target. Chimeric, human-like and humanized antibodies have generally been described in the art. Generally, such chimeric, human-like or humanized antibodies comprise hypervariable regions, e.g., complementarity determining regions (CDRs) from a mammalian animal, *i.e.*, a mouse, and a human framework region. See, e.g., Queen, et al., Proc. Nat'l Acad. Sci. USA 86:10029 (1989), Verhoeyan, et al., Science 239:1534-1536 (1988). By incorporating as little foreign sequence as possible in the hybrid antibody, the antigenicity is reduced. Preparation of these hybrid antibodies may be carried out by methods well known in the art.

Preferred antibodies are those monoclonal or polyclonal antibodies which specifically recognize and bind to human RAGE proteins and more particularly, those that specifically bind to the human soluble RAGE polypeptides of the invention. Accordingly, these preferred antibodies will specifically recognize and bind the polypeptides which have an amino acid sequence that is substantially homologous to the amino acid sequence shown in Figure 1A and 1B (Seq ID NOS: 2 and 4), or immunologically active fragments thereof. Still more preferred are antibodies which are capable of forming an antibody-ligand complex with the polypeptides of the invention, whereby the ability of the RAGE polypeptides to associate with their ligands, *in vitro*, is reduced, e.g., blocking antibodies.

Also preferred are blocking antibodies which inhibit or reduce binding of RAGE to other natural and pathology associated ligands of human RAGE, e.g., amphoterin,  $\beta$ -amyloid peptides, and the like.

#### IV. Nucleic Acids and Cell Lines

In another aspect, the present invention provides nucleic acids which encode the polypeptides of the invention, as well as expression vectors that include  
5 these nucleic acids, and cell lines and organisms that are capable of expressing these nucleic acids. These nucleic acids, expression vectors and cell lines may generally be used to produce the polypeptides of the invention. Generally, the isolated nucleic acids of the present invention encode a polypeptide which is derived from or related to a soluble human RAGE polypeptide or biologically active  
10 fragment thereof.

In preferred aspects, the nucleic acid compositions of the invention will typically include a coding region which encodes a polypeptide having an amino acid sequence that is substantially homologous to the amino acid sequence shown in Figure 1A and 1B (Seq ID NOS: 1-4). Preferred nucleic acids will typically encode  
15 polypeptides having an amino acid sequence which is substantially homologous to the amino acid sequence shown in Figure 1A and 1B (Seq ID NOS: 1-4), or biologically active fragments thereof. Such fragments will generally comprise a segment of from about 15 to about 150 nucleotides. These fragments can be useful as oligonucleotide probes in the methods of the present invention, or alternatively to  
20 encode the polypeptides or biologically active fragments of the present invention, described herein. Also provided are substantially similar nucleic acid sequences, allelic variations and natural or induced sequences of the above described nucleic acids. Also included are chemically modified and substituted nucleic acids, e.g., those which incorporate modified nucleotide bases or which incorporate a labelling  
25 group.

More preferred nucleic acids will comprise a segment having more than about 20 contiguous nucleotides from the nucleotide sequences shown in either of Figure 1A or 1B (Seq ID NOS: 1 and 3), with still more preferred nucleic acids having a nucleotide sequence that is substantially homologous to either of the  
30 nucleotide sequences shown in Figure 1A or 1B (Seq ID NOS: 1 and 3). Most preferred nucleic acids are those which include a portion, i.e., at least 20 contiguous nucleotides, or all of the nucleotide sequence shown in Figures 1A or B (Seq ID NOS: 1 and 3).

"Nucleic acids" of the present invention include RNA, cDNA, genomic  
35 DNA, synthetic forms and mixed polymers, both sense and antisense strands. Furthermore, different alleles of each isoform are also included. The present invention also provides recombinant nucleic acids which are not otherwise naturally occurring. The nucleic acids described herein also include self replicating plasmids and infectious polymers of DNA or RNA. Unless specified otherwise, conventional

notation for nucleic acids is used herein. For example, as written, the left hand end of a single stranded polynucleotide sequence is the 5'-end, whereas the right-hand end is the 3'-end. The left hand direction of double-stranded polynucleotide sequences is referred to as the 5' direction. The direction of 5' to 3' addition of nascent RNA transcripts is referred to as the transcription direction; sequence regions on the DNA strand having the same sequence as the RNA and which are 5' to the 5' end of the RNA transcript are referred to as "upstream sequences"; sequence regions on the DNA strand having the same sequence as the RNA and which are 3' to the 3' end of the RNA transcript are referred to as "downstream sequences".

The phrase "nucleic acid sequence encoding" refers to a nucleic acid which directs the expression of a specific protein or peptide. The nucleic acid sequences include both the DNA strand sequence that is transcribed into RNA and the RNA sequence that is translated into protein. The nucleic acid sequences include both the full length nucleic acid sequences as well as non-full length sequences derived from the full length protein. It will be further understood that the nucleic acids of the invention also encompass degenerate codons of the native sequence or sequences which may be introduced to provide codon preference in a specific host cell.

Substantial homology in the nucleic acid context means that the segments, or their complementary strands, when compared, are the same when properly aligned, with the appropriate nucleotide insertions or deletions, in at least about 60% of the nucleotides, typically, at least about 70%, more typically, at least about 80%, usually, at least about 90%, and more usually, at least about 95% to 98% of the nucleotides. Alternatively, substantial homology exists when the segments will hybridize under selective hybridization conditions to a strand, or its complement, typically using a sequence of at least about 20 contiguous nucleotides derived from the nucleotide sequences shown in Figures 1A or 1B (Seq ID NOS: 1 and 3). However, larger segments will usually be preferred, *e.g.*, at least about 30 contiguous nucleotides, more usually about 40 contiguous nucleotides, and preferably more than about 50 contiguous nucleotides. Selective hybridization exists when hybridization occurs which is more selective than total lack of specificity. See, Kanehisa, Nucleic Acid Res. 12:203-213 (1984). Examples of such selective hybridization conditions include, *e.g.*, hybridization under the hybridization and wash conditions of 50% formamide at 42°C. Other stringent hybridization conditions may also be selected. Generally, stringent conditions are selected to be about 5° C lower than the thermal melting point ( $T_m$ ) for the specific sequence at a defined ionic strength and pH. The  $T_m$  is the temperature (under defined ionic strength and pH) at which 50% of the target sequence hybridizes to a

perfectly matched probe. Typically, stringent conditions will be those in which the salt concentration is at least about 0.02 molar at pH 7 and the temperature is at least about 60°C. As other factors may significantly affect the stringency of hybridization, including, among others, base composition and size of the complementary strands, the presence of organic solvents and the extent of base mismatching, the combination of parameters is more important than the absolute measure of any one.

The nucleic acids of the present invention may be present in whole cells, cell lysates or in partially pure or substantially pure or isolated form. When referring to nucleic acids, the terms "substantially pure" or "isolated" generally refer to the nucleic acid separated from contaminants with which it is generally associated, e.g., lipids, proteins and other nucleic acids. The substantially pure or isolated nucleic acids of the present invention will be greater than about 50% pure. Typically, these nucleic acids will be more than about 60% pure, more typically, from about 75% to about 90% pure and preferably from about 95% to about 98% pure.

There are various methods of isolating the nucleic acids which encode the polypeptides of the present invention. Typically, the DNA is isolated from a genomic or cDNA library using labeled oligonucleotide probes specific for sequences in the desired DNA. Restriction endonuclease digestion of genomic DNA or cDNA containing the appropriate genes can be used to isolate the DNA encoding the polypeptides of the invention. From the nucleotide sequence given in Figures 1A or 1B (Seq ID NOS: 1 and 3), a panel of restriction endonucleases can be constructed to give cleavage of the DNA in desired regions, i.e., to obtain segments which encode biologically active polypeptides or fragments of the invention. Following restriction endonuclease digestion, DNA encoding the polypeptides of the invention is identified by its ability to hybridize with a nucleic acid probe in, for example, a Southern blot format. These regions are then isolated using standard methods. See, e.g., Sambrook, et al., *supra*.

The polymerase chain reaction, or "PCR" can also be used to prepare nucleic acids which encode the polypeptides of the present invention. PCR technology is used to amplify nucleic acid sequences of the desired nucleic acid, e.g., the DNA which encodes the polypeptides of the invention, directly from mRNA, cDNA, or genomic or cDNA libraries. Alternatively, solid phase oligonucleotide synthesis methods may also be employed to produce the nucleic acids described herein. Such methods include the phosphoramidite method described by, e.g., Beaucage and Carruthers, *Tetrahedron Lett.* 22:1859-1862 (1981), or the triester method according to Matteucci, et al., *J. Am. Chem. Soc.*, 103:3185 (1981). A double stranded fragment may then be obtained, if desired, by annealing the

chemically synthesized single strands together under appropriate conditions or by synthesizing the complementary strand using DNA polymerase with an appropriate primer sequence.

Appropriate primers and probes for amplifying the nucleic acids described herein, may be generated from analysis of the nucleic acid sequences described herein, e.g., in Figure 1A or 1B (Seq ID NOS: 1 and 3). Briefly, oligonucleotide primers complementary to the two 3' borders of the DNA region to be amplified are synthesized. The PCR is then carried out using the two primers. See, e.g., PCR Protocols: A Guide to Methods and Applications (Innis, M., Gelfand, D., Sninsky, J. and White, T., eds.) Academic Press (1990). Primers can be selected to amplify a variety of different sized segments from the nucleic acid sequence.

In addition to their use in producing the polypeptides of the invention, the nucleic acid sequences described herein are also particularly useful in a number of other applications. For example, in a particular aspect, the nucleic acid sequences of the present invention or fragments thereof, may be readily employed as nucleic acid probes useful in obtaining genes which encode the polypeptides of the present invention or other closely related genes. "Nucleic acid probes" may be DNA or RNA fragments. DNA fragments can be prepared, for example, by digesting plasmid DNA, or by use of PCR, or synthesized by either the phosphoramidite or phosphotriester methods described in, e.g., Gait, Oligonucleotide Synthesis: A Practical Approach, IRL Press (1990). Where a specific sequence for a nucleic acid probe is given, it is understood that the complementary strand is also identified and included. The complementary strand will work equally well in situations where the target is a double-stranded nucleic acid. Typical nucleic acid probes may be readily derived from the nucleotide sequence shown in Figure 1A or B (Seq ID NOS: 1 and 3), or alternatively, may be prepared from the amino acid sequence of soluble human RAGE polypeptides, as shown in Figure 1A or 1B (Seq ID NOS: 2 and 4). In particular, probes may be prepared based upon segments of the amino acid sequence which possess relatively low levels of degeneracy, i.e., few or one possible nucleic acid sequences which encode therefor. Suitable synthetic DNA fragments may then be prepared.

Such nucleic acid probes, e.g., cDNA probes, may be used in the design of oligonucleotide probes and primers for screening and cloning genes which encode the polypeptides of the invention or related polypeptides, e.g., using well known PCR techniques. These nucleic acids, or fragments may comprise part or all of the cDNA sequence that encodes the polypeptides of the present invention. Effective cDNA probes may comprise as few as 15 consecutive nucleotides in the cDNA sequence, but will often comprise longer segments. Further, these probes

may further comprise an additional nucleotide sequence, such as a transcriptional primer sequence for cloning, or a detectable group for easy identification and location of complementary sequences. Examples of probes that are particularly useful in amplifying the nucleic acid sequence encoding soluble human RAGE as shown in Figure 1A or 1B, include those having the following sequences:

5'-GATGGCAGCCGGAACAGCAGTT-3' (Seq ID NO: 22); and

5'-CTCAAGTTCCTCAGCCCTGATCCTCC-3' (Seq ID NO: 23).

cDNA or genomic libraries of various types may be screened for new alleles encoding RAGE or related sequences, using the above probes. The choice of cDNA libraries normally corresponds to tissue sources which are abundant in mRNA for the desired polypeptides, e.g., lung tissue. Phage or plasmid libraries may generally be used. Clones of a library are spread onto plates, transferred to a substrate for screening, denatured, and probed for the presence of the desired sequences.

In addition to comprising a segment which encodes one or more of the above described polypeptides or biologically active fragments, the nucleic acids of the present invention may also comprise a segment encoding a heterologous protein, such that the gene is expressed to produce the two proteins as a fusion protein, as substantially described above.

Typically, the nucleic acids of the present invention will be used in expression vectors for the preparation of the polypeptides of the present invention, namely those polypeptides which are derived from or related to soluble human RAGE or its biologically active fragments. The phrase "expression vector" generally refers to nucleotide sequences that are capable of affecting expression of a structural gene in hosts compatible with such sequences. These expression vectors typically include at least suitable promoter sequences and optionally, transcription termination signals. Additional factors necessary or helpful in effecting expression may also be used as described herein. DNA encoding the RAGE polypeptides of the present invention will typically be incorporated into DNA constructs capable of introduction into and expression in an *in vitro* cell culture. Often, the nucleic acids of the present invention may be used to produce a suitable recombinant host cell. Specifically, DNA constructs will be suitable for replication in a prokaryotic host, such as bacteria, e.g., *E. coli*, or may be introduced into a cultured mammalian, plant, insect, e.g., Sf9, yeast, fungi or other eukaryotic cell line. DNA constructs prepared for introduction into a particular host, e.g., insect or bacteria, will typically include a replication system recognized by the host, the intended DNA segment encoding the desired polypeptide, and transcriptional and translational initiation and termination regulatory sequences operably linked to the polypeptide encoding segment. A DNA segment is operably linked when it is

placed into a functional relationship with another DNA segment. For example, a promoter or enhancer is operably linked to a coding sequence if it stimulates the transcription of the sequence. DNA for a signal sequence is operably linked to DNA encoding a polypeptide if it is expressed as a preprotein that participates in the secretion of the polypeptide. Generally, DNA sequences that are operably linked are contiguous, and in the case of a signal sequence both contiguous and in reading phase. However, enhancers need not be contiguous with the coding sequences whose transcription they control. Linking is accomplished by ligation at convenient restriction sites or at adapters or linkers inserted in lieu thereof. The selection of an appropriate promoter sequence will generally depend upon the host cell selected for the expression of the DNA segment. Examples of suitable promoter sequences include prokaryotic, and eukaryotic promoters well known in the art. See, e.g., Sambrook et al., *Molecular Cloning: A Laboratory Manual* (2d ed.), vols. 1-3 Cold Spring Harbor Laboratory (1989). The transcriptional regulatory sequences will typically include a heterologous enhancer or promoter which is recognized by the host. The selection of an appropriate promoter will depend upon the host, but promoters such as the trp, lac and phage promoters, tRNA promoters and glycolytic enzyme promoters are known and available. See Sambrook et al., (1989).

Conveniently available expression vectors which include the replication system and transcriptional and translational regulatory sequences together with the insertion site for the polypeptide encoding segment may be employed. Examples of workable combinations of cell lines and expression vectors are described in Sambrook et al., and in Metzger et al., *Nature* 334:31-36 (1988). For example, suitable expression vectors may be expressed in, e.g., insect cells, e.g., Sf9 cells, mammalian cells, e.g., CHO cells and bacterial cells, e.g., *E. coli*.

Where an insect cell line is selected as the host cell of choice to express the polypeptide, the cDNA encoding the polypeptides of the invention may be cloned into an appropriate baculovirus expression vector, e.g., pBacPAK8 vector (Clontech, Palo Alto, CA). The recombinant baculovirus may then be used to transfect a suitable insect host cell, e.g., *Spodoptera frugiperda* (Sf9) cells, which may then express the polypeptide. See, e.g., D.K. Morrison et al., *Cell* 58:649-657 (1989), M.D. Summers and G.E. Smith, *A Manual of Methods for Baculovirus Vectors and Insect Cell Culture Procedures*, Texas Agricultural Station, College Station, Texas (1987).

## V. Methods of Use

The compositions of the present invention have a wide variety of uses, including, inter alia, screening, diagnostic and therapeutic applications.

5

### A. Screening Applications

In a preferred aspect, the polypeptides of the invention may be used as model systems for identifying effectors of the AGE/RAGE interaction. In particular, these model systems may be used to screen collections or libraries of test compounds in order to identify agonists or antagonists of AGE/RAGE interaction. Generally, agonists, antagonists or test compounds may be chemical compounds, mixtures of chemical compounds, biological macromolecules, or extracts made from biological materials such as bacteria, plants, fungi, or animal cells or tissues. Particularly targeted test compounds will typically include the polypeptides or fragments of the present invention as well as structural analogs or peptidomimetics which are derived from these polypeptides or the antibodies described herein, substrates or ligands thereof. As used herein, the term "agonist" refers to a composition or compound that will enhance the particular observed activity, e.g., AGE/RAGE binding, while an "antagonist" will diminish the particular observed activity. The terms "agonist" and "antagonist", as used herein, do not imply any particular mechanism of function.

The screening methods of the present invention typically involve the incubation of a polypeptide of the present invention, e.g., a soluble human RAGE polypeptide, in the presence of a standard advanced glycosylation end-product protein (AGE) such as AGE-BSA, nonenzymatically N-glycosylated collagen, myelin or the like, as well as the test compound. Typically, one of the RAGE polypeptide or AGE will be immobilized upon a solid support which will then be contacted with the other protein or peptide. The other, non-immobilized member of the AGE/RAGE pair will typically include a labeling group covalently or otherwise attached so as not to interfere with the AGE/RAGE interaction. Labeling groups will generally include those that are substantially set out above. Immobilization of one of the AGE or RAGE polypeptide permits ready separation of AGE/RAGE complex, which will be bound to the solid support, from unreacted or free AGE or RAGE, utilizing a simple wash step.

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A number of suitable solid supports may be employed for immobilization of the AGE or RAGE polypeptides. Examples of suitable solid supports include agarose, cellulose, dextran, Sephadex, Sepharose, carboxymethyl cellulose, polystyrene, filter paper, nitrocellulose, ion exchange resins, plastic films,



## B. Affinity Ligands

In addition to their use as screening systems, the peptides of the invention may also be used as affinity ligands which specifically bind to AGEs. As  
5 affinity ligands, these polypeptides may also be useful in the purification of AGEs from a mixture of different proteins. Affinity purification of AGEs may be carried out using affinity purification methods that well known in the art. For example, the soluble RAGE polypeptide or peptides may be attached to a suitable solid support as described above. Many solid supports are commercially available from, e.g.,  
10 Sigma Chemical Co., St Louis, Missouri, or Pharmacia, Uppsala, Sweden, and come prepared for immediate coupling of affinity ligands.

The mixture of proteins may be contacted with the polypeptide bound to the solid support, such that the RAGE polypeptide immobilized upon the solid support can selectively bind the AGEs within the mixture of proteins. The bound  
15 protein can then be washed to eliminate unbound proteins. Finally, substantially pure AGEs may be eluted from the solid support by generally known elution protocols, e.g., changing buffer conditions, temperature, or level of carbohydrate in the elution buffer.

As affinity probes, the polypeptides of the invention may also be used  
20 to bind AGEs both *in vitro* and *in vivo*. This binding may be used in assay formats to label and detect AGEs in a sample, imaging formats to identify localization of AGEs in a patient, or in therapeutic applications to deliver a drug to areas which are relatively high in AGE concentration, or specifically deliver a drug, e.g., a proteolytic drug, to an AGE.

25 In a similar manner, the antibodies of the invention may also be used as affinity probes or ligands for soluble RAGE polypeptides. In particular, the specificity of the antibodies of the invention may be exploited in the purification and/or identification of RAGE polypeptides and particularly, soluble human RAGE polypeptides.

30

## C. Diagnostic Applications

As alluded to above, the polypeptides of the invention may be used as probes capable of specifically interacting with their ligands, i.e., AGEs. As a result,  
35 the polypeptides of the invention may be used in a variety of diagnostic applications. For example, those polypeptides of the invention that are capable of specifically interacting with AGEs may be particularly useful in identifying patients who may suffer from abnormal levels of AGEs which are indicative of particular

glass beads, polyaminemethylvinylether maleic acid copolymer, amino acid copolymer, ethylene-maleic acid copolymer, nylon, silk, etc. The support may be in the form of, e.g., a test tube, microtiter plate, beads, test strips, or the like. The reaction of the AGE or RAGE polypeptide with the particular solid support may be carried out by methods well known in the art. For example, in some cases, supports bearing lectins, e.g., Con-A, may be employed for immobilization of the AGEs. Alternatively, a variety of pre-derivatized solid supports to which AGEs may be covalently attached are generally available from, e.g., Sigma Chemical Co. (St. Louis, MO), and Pharmacia (Upsalla, Sweden).

In the case of a microtiter plate, the test compound may be added to the well of the microtiter plate to preincubate with the immobilized AGE or RAGE polypeptide. The remaining member of the RAGE/AGE pair, bearing a suitable labeling group as described previously, may then be added to the microtiter well. Following suitable incubation, the wells are washed, and the amount of bound label is determined, e.g., by scanning the plate with a suitable optical reader, e.g., plate reader. The level of binding is then compared to suitable positive and negative controls or a set of standards containing a known range of agonists or antagonist concentrations. Alternatively, by providing the polypeptide containing the RAGE and AGE polypeptides in known concentrations, one can assay for the level of free or unbound RAGE or AGE, and by negative implication, determine the level of RAGE/AGE complex which is formed.

In some cases, identification of complexed AGE/RAGE may be carried out by other means, i.e., without the use of a support bound peptide. For example, well known quantitation methods, such as HPLC and the like may be utilized to separate and identify complexed AGE/RAGE polypeptides from the free or uncomplexed proteins. Again, this may allow determination and comparison of the amount of either the free or bound material remaining after incubation with the test compound.

Where the presence of the test compound results in a decrease of the amount of RAGE/AGE complex formed, it will be indicative that the test compound is an antagonist of the RAGE/AGE interaction. Where, however, the presence of a test compound results in an increase or enhancement of RAGE/AGE interaction, it will be indicative that the compound is an agonist of the RAGE/AGE interaction. Test compounds which are indicated to be antagonists of the RAGE/AGE interaction may be further characterized in additional studies, e.g., clinical trials.

disorders, or may be viewed as indicators of future problems, such as diabetic vasculopathy.

In a particular aspect, soluble human RAGE polypeptides may be used as affinity probes to identify the presence, absence and/or relative quantity of AGEs in a sample, e.g., blood or tissue samples from a patient. This allows the identification of patients having elevated levels of AGE or other ligands of RAGE, which levels are indicative of a variety of pathological conditions associated with, e.g., Diabetes Mellitus, peripheral occlusive vascular diseases, hemodialysis-associated amyloidosis, Alzheimer's disease and other age-related disorders. Once a patient is diagnosed as suffering from one or more of these complications, or is identified as being at a higher risk, appropriate preventative or therapeutic measures may be taken, such as administration of appropriate pharmaceutical agents, e.g., compositions comprising the peptides, peptidomimetics or antibodies of the invention.

In a similar manner, the antibodies of the present invention, e.g., those that are specifically immunoreactive with human RAGE polypeptides, may be used to diagnose disorders characterized by abnormal levels or localization of AGE/RAGE interactions. In particular, the described antibodies may be used as diagnostic tools to evaluate plasma and tissue levels of RAGE in patients suffering from pathological conditions associated with elevated levels of AGE/RAGE interaction. In particular, the antibodies described herein may be used in well known immunoassay formats, e.g., ELISA, Western blotting, immunohistochemistry and FACS methods, to identify levels of RAGE in samples.

#### 25 D. Therapeutic Applications

In addition to the above described uses, the soluble RAGE polypeptides and antibodies of the invention may also be used in therapeutic applications for the treatment of human or non-human mammalian patients. The term "treatment" as used herein, refers to the full spectrum of treatments for a given disorder from which the patient is suffering, including alleviation of one, most or all symptoms resulting from that disorder, to an outright cure for the particular disorder or prevention of the onset of the disorder.

In particular, the polypeptides and antibodies of the invention are useful in treating disorders or symptoms of which result from excessive levels of AGEs in tissue or plasma. As described previously, the association of AGEs and RAGE has been implicated as a symptom or causative event in a number of pathological conditions including, e.g., complications associated with Diabetes Mellitus, e.g., diabetic microvasculopathy (neuropathy, nephropathy and

retinopathy), diabetic macrovasculopathy (atherosclerosis), occlusive vascular disorders, activation of microglial cells by  $\beta$ -amyloid peptides in Alzheimer's disease, hemodialysis-associated amyloidosis and age related disorders such as oxidant stress. Accordingly, treatment or prevention of such disorders may generally be carried out by reducing, inhibiting or outright blocking the interaction between AGEs and RAGE. Blocking this interaction typically involves administering to a patient an effective amount of a soluble human RAGE polypeptide, peptidomimetic or blocking antibody, as described above.

The term "patient" generally refers to a mammalian individual, typically human, who has been diagnosed as suffering from one or more of the above described disorders, or who has been characterized as belonging to a group that has an abnormally high incidence of such disorders, e.g., diabetics and the elderly.

The term "effective amount" or "therapeutically effective amount" generally refers to the quantities of reagents necessary for effective therapy, i.e., the partial or complete alleviation of the symptom or disorder for which treatment was sought. Included within the definition of effective therapy are preventative treatments intended to reduce the likelihood of onset of the above-described symptoms or disorders. The effective amount for a given therapy, whether curative or preventative, will generally depend upon many different factors, including means of administration, target site, physiological state of the patient and other medicants administered. Thus, treatment doses will need to be titrated to optimize safety and efficacy. Typically, dosages used *in vitro* may provide useful guidance in the amounts useful for *in situ* administration of these reagents. Animal testing of effective doses for treatment of particular disorders will provide further predictive indication of human dosage. Generally, therapeutically effective amounts of the polypeptides or blocking antibodies of the present invention will be from about 0.0001 to about 10 mg/kg, and more usually, from about 0.001 to about 0.1 mg/kg of the host's body weight. Various considerations are described, e.g., in Gilman et al., (Eds.), *Goodman and Gilman's: The Pharmacological Basis of Therapeutics*, (8th ed. 1990), Pergamon Press, and *Remington's Pharmaceutical Sciences* (7th ed. 1985) Mack Publishing Co., Easton, Penn.

Methods of administration, also discussed in the above references, include, e.g., oral, intravenous, intraperitoneal or intramuscular administration, and local administration, including topical, transdermal diffusion and aerosol administration, for therapeutic, and/or prophylactic treatment. The active agent, i.e., the polypeptide or antibody component, will generally be administered in a composition additionally comprising a pharmaceutically acceptable carrier. Suitable pharmaceutically acceptable carriers include water, saline, buffers and other compounds described in, e.g., the Merck Index, Merck and Co., Rahway, New

Jersey. For some methods of administration, e.g., oral, it may be desirable to provide the active ingredient in a liposomal formulation. This is particularly desirable where the active ingredient may be subject to degradative environments, for example, proteolytic digestive enzymes. Liposomal formulations are well known in the art, and are discussed in, e.g., Remington's Pharmaceutical Sciences, *supra*. Administration may also be carried out by way of a controlled release composition or device, whereby a slow release of the active ingredient allows continuous administration over a longer period of time.

Constituents of pharmaceutical compositions, in addition to the active agents described herein, include those generally known in the art for the various administration methods used. For example, oral forms generally include powders, tablets, pills, capsules, lozenges and liquids. Similarly, intravenous, intraperitoneal or intramuscular formulations will generally be dissolved or suspended in a pharmaceutically acceptable carrier, e.g., water, buffered water, saline and the like. Additionally, these compositions may include additional constituents which may be required to approximate physiological conditions, such as pH adjusting and buffering agents, tonicity adjusting agents, wetting agents and the like. For solid compositions, conventional nontoxic solid carriers may be used which include, e.g., pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, sodium saccharin, talcum, cellulose, glucose, sucrose, magnesium carbonate and the like.

Administration may also be carried out by way of a controlled release composition or device, whereby a slow release of the active ingredient allows continuous administration over a longer period of time.

The present invention is further illustrated by the following examples. These examples are merely to illustrate aspects of the present invention and are not intended as limitations of this invention.

## VI. Examples

### 30 Example 1: Cloning, Expression and Purification of Soluble Human RAGE

A DNA fragment coding for human soluble RAGE was obtained from lung cDNA library using polymerase chain reaction techniques (PCR, GeneAmp, Perlin-Elmer Cetus); primers used were 5'-GATGGCAGCCGG AACAGCAGTT-3' (Seq ID NO: 22) and 5'-CTCAAGTTCCCAGCCCTGATCCTCC-3' (Seq ID NO: 23). The DNA sequence of the PCR product was confirmed by the dideoxy chain termination method (Sanger, et al., Proc. Nat'l Acad. Sci. USA 74:5463-5467 (1977)). The DNA fragment was subcloned into the pCRII™ vector (Invitrogen, San Diego, CA) and the EcoR1 fragment of the resulting plasmid was cloned into the pBacPAK8 vector (Clontech, Palo Alto, CA) under control of the AcMNPV

polyhedrin promoter (ATCC Accession Nos. VR-2538 and VF-25-39). Baculovirus expression of recombinant human soluble RAGE was performed by co-transfecting the plasmid pBacPAK8/RAGE with a linearized BacPAK6 viral cDNA (Clontech) into *Spodoptera frugiperda* (Sf9) cells according to the manufacturer's instructions.

- 5 Recombinant plaques were identified and purified by their beta-galactosidase negative phenotype.

Sf9 cells expressing soluble RAGE were grown as follows: Non-infected Sf 9 cells were grown in shake flasks at 28°C, to a density of  $1 - 1.2 \times 10^6$ /ml in TNMF (Grace's with supplements from Sigma) plus 10% FBS (e.g. 10 Hyclone) and 0.1% pluronic F-68 (Sigma), and a viability of >97%. One liter of cells was infected with viral stock (MOI of ~ 0.01). Cultures were harvested 3 days post-infection by centrifuging the media at 1200 rpm for 8 min. This media was then used for purification of recombinant soluble RAGE.

- 15 Recombinant human soluble RAGE was purified from the Sf9 media by chromatography on an SP Sepharose fast flow column (Pharmacia) followed by a size exclusion chromatography step. In particular, a 1/10 volume of 1.0 M Tris-HCl, pH 8.0 was added to Sf 9 cell media to precipitate viral proteins and the media was allowed to sit at 4°C for several hours to allow precipitation. The precipitated media was centrifuged at ~ 3000 rpm for 10 to 15 min to remove any precipitate. 20 The supernatant was diluted 1:4 with deionized water, adjusted to pH 7.5 and sterile filtered (0.2 µm). The filtered supernatant was loaded onto SP Sepharose fast flow column (#17-0729-01, Pharmacia), that had been equilibrated with 20 mM NaPO<sub>4</sub>, pH 7.5. The column was eluted in a salt gradient from 0 to 0.5 M NaCl, and the fractions were analyzed by SDS-PAGE. Fractions containing RAGE were pooled, 25 concentrated and diafiltered into PBS buffer.

Further purification was obtained by applying the pooled fractions to a Superdex 200PG column, and again, fractions were analyzed by SDS-PAGE and pooled as appropriate.

30 **Example 2: Solid Phase Binding Assays for Soluble Human RAGE**

- Two assay formats were used to assess the ability of soluble RAGE to bind AGE. The first provided a RAGE polypeptide immobilized directly to the solid support whereas the second method employed an indirect attachment to more closely mimic the cell surface presentation of the AGE binding portion of 35 RAGE.

### A. Preparation of AGE-BSA and $^{125}\text{I}$ -AGE-BSA

Bovine serum albumin (from Sigma, Cat #A7888) was incubated at a concentration of 25 mg/ml in phosphate buffered saline (calcium- and magnesium-free) with 250 mM ribose, in the presence of 1.5 mM PMSF (phenylmethylsulfonyl fluoride) and 1 mM EDTA (ethylenediaminetetraacetic acid). The pH of the solution was adjusted to between 6.8 and 7.0. The solution was sterilized by filtering through 0.22 micron filters and incubated in dark, at 37°C for 6 to 8 weeks. The solution containing AGE-BSA was dialysed against calcium- and magnesium-free PBS, and stored frozen in aliquots at -20°C.

100 µg of AGE-BSA was iodinated with 1 mCi of  $\text{Na}^{125}\text{I}$  using iodogen method according to the manufacturer's specifications. 4 µl of AGE-BSA (~ 100 µg), 8 µl of  $\text{Na}^{125}\text{I}$  (1 mCi) and 88 µl of phosphate buffered saline was added to a tube containing iodo-gen (Pierce). The tube was incubated for 15 minutes on ice, with occasional agitation. The reaction was terminated by adding 50 µl of 0.1% potassium iodide. The reaction mixture was passed over a desalting column to remove free iodine.

### B. Competitive Binding of AGE to Indirectly Immobilized RAGE

A 96-well plate (Immunolon 4 from Dynatech Lab) was coated with anti-flag peptide antibodies (Eastman Kodak), 100 µl/well of 17 µl/ml in sodium bicarbonate buffer, pH 9.6) at 4°C overnight. The wells were washed and blocked as above. The wells were then incubated with Sf 9 media containing human recombinant soluble RAGE/flag fusion protein (75 µl of 1:4 dilution with PBS) 1 to 2 h at 37°C (flag peptide: DYKDDDDK). The wells were again washed as before and incubated with various concentrations of  $^{125}\text{I}$ -AGE-BSA alone or in the presence of excess cold AGE-BSA (i.e., nonradioactive) in PBS containing 0.2% BSA (45 µl/well) at room temperature for 2-3 hours. The sample having an excess of cold AGE-BSA was used to account for nonspecific interactions. The wells were washed twice with 0.2% BSA in PBS. The bound ligand was then eluted with PBS containing 1 mg/ml of heparin and 1 mg/ml of BSA (100 µl/well) by incubating at 37°C for 5 minutes and counted. Figure 2 shows a graph of AGE binding to indirectly immobilized RAGE (expressed as CPM) as a function of increasing ligand concentration, in the absence and presence of excess nonradioactive ligand (Figure 2A), and corrected for nonspecific interactions (Figure 2B).

**Example 3: Competition Binding Assays Using Soluble Human RAGE**

Competition assays were also performed between  $^{125}\text{I}$ -AGE-BSA and an excess of a number of other proteins, including soluble RAGE, Soluble RAGE/flag fusion protein, recombinant soluble RAGE/DCC chimeric protein (where the first Ig-like domain of RAGE is substituted with the first Ig-like domain of DCC, another Ig-superfamily member), lactoferrin and native BSA. The results are shown in Table 1, below.

Table 1

Results of Competition Binding Assay (% Binding)			
	Exp. 1	Exp. 2	Exp. 3
$^{125}\text{I}$ -AGE-BSA only	100%	100%	100%
+ cold AGE-BSA	29%	14%	12%
+ rec. solRAGE	n.d.	65%	60%
+ rec. solRAGE/flag fusion	8%	n.d.	n.d.
+ rec. solRAGE/DCC chimeric	40%	n.d.	n.d.
+ lactoferrin	n.d.	50%	20%
+ native BSA	n.d.	>100%	>100%

10

n.d. - Not determined

Binding assays were done in quadruplicate. Lactoferrin has been previously shown to bind AGEs. Li et al. Nature med. 1(10):1057-1061 (1995). Furthermore, lactoferrin was also shown to bind to RAGE Schmidt et al., J. Biol. Chem. 269:9882-9888 (1994), Yan et al., J. Biol. Chem. 269:9889-9897 (1994). However, as is apparent from the Table 1, binding of lactoferrin to RAGE or AGE does not facilitate further binding of AGE-BSA to RAGE. Figure 3 is dose response curve for the formation of RAGE/AGE binding complex in the presence of increasing concentrations of soluble RAGE polypeptide. As shown, increasing concentration of soluble RAGE increased the levels of AGE/RAGE binding until a plateau was reached.

25



**Example 4: Preparation of Antibodies to Human Soluble RAGE**

Monoclonal antibodies were generated from mice immunized with the human soluble RAGE extracellular domain expressed in baculovirus as described above.

5                   Hybridoma preparation: Pairs of mice from three strains (Balb/C, Swiss Webster, and RBF/DnJ) were immunized with 100 µg soluble RAGE in complete Hunter's adjuvant, intradermally, on days 0, 7, and 21. Sera were drawn on day 28, and titers tested by EIA of soluble RAGE and FACS analysis of CHO-RAGE transfectants. Two mice were selected as lymphocyte donors, and received  
10 5 µg soluble RAGE IV 72 hours before fusion. Splenocytes from these mice were fused with the mouse myeloma P3X63Ag8.653, and the resultant fusion products were selected with hypoxanthine-aminopterin-thymidine (HAT). Following HAT selection, supernatants from 2100 clones were tested in direct EIA with soluble RAGE. Seventy two strongly positive clones were isolated and then tested for  
15 reactivity to CHO RAGE transfectant cells, of which 69 clones were positive. Selected hybridomas were serially subcloned 3X by limiting dilution, and ascites induced in pristane primed ICRF1 mice. The antibodies were purified by affinity chromatography (Protein G) followed by ion exchange chromatography (Q-Sepharose). Purity was tested by reduced SDS-PAGE, and isotype analysis was  
20 done by radial immunodiffusion.

The resultant panel was tested for reactivity by EIA, Western blot, and FACS analysis of CHO cells transfected with full length RAGE. The antibodies were also analyzed for epitope variance by competition, and reactivity with RAGE/DCC chimeric protein. Complementary pairs of antibodies were selected,  
25 and antigen capture EIAs specific for human, rat, and mouse RAGE were designed, with sensitivity in the nanogram range.

EIA: Direct antibody capture EIA was done by coating 96-well microtiter plates with 1 µg/well antigen in PBS, and incubating overnight at 4 C. Wells were blocked with PBS/1% BSA or casein, anti-RAGE antibodies added as  
30 either neat tissue culture supernatant or 1 µg/well diluted in PBS/1% BSA and incubated for 2 hours at ambient room temperature. After washing 3X with PBS, anti-mouse IgG-alkaline phosphatase was added, and substrate degradation analyzed at 405 nm with a UVMax plate reader.

Antigen capture (sandwich) EIAs were done as above, with the  
35 additional step of coating wells with 2 µg anti-RAGE monoclonal antibody diluted in carbonate buffer, pH 9.6, before addition of antigen.

Western Blot: Cell culture supernatants containing human, rat, or mouse RAGE were harvested, and size fractionated on denaturing SDS-PAGE

gels. The proteins were transferred to nitrocellulose, incubated with anti-RAGE antibody, and developed using an Amersham detection kit.

FACS analysis: Cells (CHO-RAGE, parental CHO, mouse macrophage, and human smooth muscle aorta) were harvested, and incubated with 5  $\mu$ g per  $10^6$  cells anti-RAGE antibody for 45 minutes on ice. After washing with cold PBS, cells were then incubated with anti-mouse IgG-FITC or phycoerythrin for 45 minutes on ice and then washed with PBS. Cells were analyzed for mean channel fluorescence with a Becton-Dickinson FACScan.

Ligand binding analyses and antibody competition studies were done as above, with additional incubations with lactoferrin, and double labelled detection with anti-lactoferrin antibody in parallel with the anti-RAGE antibody.

The direct antibody capture EIA was used as the initial fusion screen to identify positive clones. The assay format was also utilized to determine reactivity with the RAGE chimeric RAGE/DCC protein in which the first immunoglobulin-like domain was replaced with that of DCC. The assay results for the first 20 MAbs are shown in Figure 4. Four MAbs recognized both intact soluble RAGE polypeptide as well as the chimeric protein indicating epitope location outside the first Ig-like domain.

Eleven antibodies were also screened for binding to soluble human RAGE polypeptide fragments as compared to their binding to soluble human RAGE. Figure 4B shows an antigen capture assay utilizing peptide fragment # 2 (WKLNTGRTEAC) (Seq ID NO: 6). The 11 antibodies were also tested for binding to immobilized RAGE in the presence and absence of free soluble RAGE or RAGE polypeptide fragment # 1 (CKGAPKKPPQ) (Seq ID NO: 5), fragment # 2 (WKLNTGRTEAC) (Seq ID NO: 6) and fragment # 8 (GPQDQGTYSYSC) (Seq ID NO: 7). The results are shown in Figure 4C.

The sandwich EIA using MAbs RBF9D9 (ATCC Accession No. HB-12165) as capture and SW10C1-biotin (ATCC Accession No. HB-12164) as detection is specific for human RAGE, and does not cross react with either rat or mouse RAGE. This assay was used to detect and quantitate the presence of RAGE expressed in baculovirus, as well as CHO cells (Figure 6A). Controls included a concentration range of purified RAGE for generation of a standard curve, as well as RAGE-spiked sera controls; the range of linearity is 20 - 100 ng/well.

A second sandwich EIA, specific for human, rat, and mouse RAGE, uses MAbs RBF9D9 (ATCC Accession No. HB-12165) as capture and SW1E8-biotin (ATCC Accession No. HB-12166) as detection. This assay was used to detect and quantitate recombinant RAGE expressed in insect and mammalian cells (Figure 6B), and sera obtained from lean and obese rats (not shown), including

controls as above. Western blot analysis of the antibodies confirms reactivity to RAGE as shown in Figure 5.

Sixty-nine of the 72 anti-RAGE MAbs were positive for binding to cell surface RAGE, as determined by direct immunofluorescent staining of CHO-RAGE transfectant cells. Data from one binding experiment is shown in Figure 7. The other 68 binding MAbs showed similar results. Additional FACS experiments included direct immunofluorescent staining of cells with anti-RAGE MAbs SW10C1 (ATCC Accession No. HB-12164), SW1E8 (ATCC Accession No. HB-12166), and RBF9D9 (ATCC Accession No. HB-12165), all of which strongly recognize cell surface RAGE.

Binding of exogenous lactoferrin, however, was clearly demonstrated on the CHO-RAGE transfectants as shown in Figure 8B. In particular, parental and RAGE transfected CHO cells were separately incubated with 5  $\mu$ g lactoferrin and stained with both anti-RAGE/phycoerythrin and anti-lactoferrin/FITC. Phycoerythrin fluorescence shown in Figure 8A, indicates the presence of RAGE on the cell surface. FITC fluorescence shown in Figure 8B indicates the binding of lactoferrin to CHO-RAGE transfectants, but not to parental CHO cells.

Epitope analysis: The results of competition experiments, binding to the deletion mutant, and binding to rat and mouse RAGE clearly indicate that the panel of MAbs recognize unique and discrete antigenic determinants. Four MAbs recognize epitopes on the second or third Ig-like domains. One of these four recognizes an epitope that is exposed on the extracellular RAGE, but not cell surface RAGE, perhaps due to proximity to the cell surface. The remaining 69 MAbs recognize epitopes on the first Ig-like domain, and bind to at least four different sites on this domain.

#### Example 5: Effects of Soluble RAGE on Vascular Permeability

Early changes in vascular permeability are widely recognized as a hallmark of diabetic vascular dysfunction. As a result, the effect of recombinant soluble RAGE was tested in permeability models. See, e.g., Vlassara et al., Laboratory Invest. 70(2):138-151 (1994), Vlassara et al., Proc. Nat'l Acad. Sci. USA 91:11704-11708 (1995).

##### A. In vitro permeability studies

Bovine aortic endothelial cells (BAEC) were cultured to confluency on nucleopore membranes. Seven days after reaching confluency, cells were incubated for 24 hours with red blood cells (RBCs) isolated from either normal subjects or diabetic patients. Endothelial cells were washed and permeability was

measured in a permeability chamber containing minimal essential medium containing 10% fetal calf serum by adding  $^{125}\text{I}$ -albumin or  $^3\text{H}$ -inulin to the upper chamber. The emergence of radioactivity in the lower chamber was then measured over 24 hours at 37°C. Aliquots of medium (5 $\mu\text{l}$ ) were sampled from the upper and lower chambers every 10 minutes for the first hour and at 1, 2, 4 and 24 hour time points to determine a permeability coefficient.

To determine the effect of recombinant soluble RAGE on in vitro permeability, normal or diabetic RBCs were first incubated with recombinant RAGE or control proteins (VCAM-1)(30 $\mu\text{g/ml}$ ) before adding to the endothelial cells.

Determination of permeability coefficient (P) was carried out by the following calculation:

$$P = (J)(1/A)(1/(C_i - C_o))$$

where J is the flux of molecules across the filter, A is the surface area of the confluent layer of endothelial cells,  $C_i$  is the concentration of tracer in the upper chamber and  $C_o$  is the concentration of tracer in the lower chamber. Post-confluent monolayers displaying permeability coefficients greater than  $6.5 \times 10^{-7} \text{ cm/s}$ , for albumin, or greater than  $5 \times 10^{-6} \text{ cm/s}$  for inulin were excluded.

When endothelial cells were exposed to diabetic RBCs, the permeability of the monolayer to both macromolecules and micromolecules increased (Figure 9A and 9B, respectively) compared with endothelial cells exposed to normal RBCs. This increased permeability was reversed by preincubation of diabetic RBCs with recombinant soluble RAGE, but not with the recombinant soluble control protein (VCAM-1, consisting of the first 3 Ig-like domains of VCAM-1 and having a structure similar to RAGE)(Figure 9A and 9B).

#### B. TBIR (tissue-blood-isotope ratio) Studies

These studies were performed with normal and diabetic male Wister rats. Diabetes was induced in the rats by intravenous injection of streptozocin (45 mg/Kg) into animals weighing approximately 200 g. Animals were maintained for 9 to 11 weeks post-STZ prior to commencing the TBIR studies. Hyperglycemia (35-40 mmol/liter) was confirmed in diabetic rats.

RBCs were collected from normal or diabetic rats by puncturing the lower abdominal aorta. The RBCs were collected in a solution of dextrose (2.4%), citric acid (2.4%), sodium citrate (0.73%) and 2 parts anticoagulant to 8 parts blood. Blood was centrifuged to remove plasma and buffy coat, and the packed RBCs were washed and infused ( $4.2 \times 10^9$  cells/animal) into normal syngeneic animals (vol. 0.5 ml). After one hour, TBIR was determined by infusion of  $^{125}\text{I}$ -albumin

followed 30 minutes later by infusion of  $^{51}\text{Cr}$ -labelled normal RBCs. Tissue and blood samples were collected 5 minutes later.

To test the effect of recombinant soluble RAGE (and the recombinant control protein), normal or diabetic RBCs were pretreated with the recombinant proteins (60  $\mu\text{g}/\text{ml}$  RBCs) prior to infusion. Six animals were used per group.

Pretreatment was carried out as follows: Diabetic rats were infused with either recombinant soluble RAGE or recombinant soluble VCAM-1 (control) (5.15 mg/Kg) 1 hour prior to TBIR measurement. In order to determine the dose of recombinant protein required to achieve a plasma concentration of 30 to 60  $\mu\text{g}/\text{ml}$ , pharmacokinetic studies were performed using  $^{125}\text{I}$ -labelled recombinant soluble RAGE, the results of which are provided in Figure 10. Radioactivity was measured as the trichloroacetic plasma precipitable fraction. Plasma human recombinant soluble RAGE concentration data were fit to a two compartment open model using nonlinear regression by extended least squares analysis (Siphar, SIMED, Cretail, France). The elimination and distribution half-lives were 26 and 0.13 hours, respectively. For TBIR studies, 10 control diabetic rats were used, 7 diabetic rats were treated with soluble RAGE and 5 rats were treated with the control protein.

TBIR was calculated as a ratio of  $[\text{}^{125}\text{I}]/[\text{}^{51}\text{Cr}]$  in tissue over the same ratio in blood. One way analysis of variance followed by Dunnet's test was used to analyze the data for each organ. The results for normal and diabetic rats are given in figures 12A and 12B, respectively.

In normal animals infused with diabetic RBCs, TBIR increased in a number of tissues as compared to infusion of normal RBCs (Figure 11A). Most of the increases in TBIR were prevented by pretreatment of diabetic rats with recombinant soluble RAGE, but not with the control protein, with the exception of kidney tissue, which showed a similar effect with both RAGE and VCAM-1. These results indicate that AGEs on the surface of diabetic RBCs interact with surface RAGE on endothelial cells, triggering activation of the latter cells. This leads to an increased permeability of the endothelial layers. Without being bound to a particular theory, it is believed that pretreatment of diabetic RBCs with soluble RAGE prevents this interaction and, as a result, prevents increases in permeability as demonstrated.

TBIR also increased in various tissues of diabetic rats as compared to those of normal rats. The increase in TBIR observed in some tissues, e.g., kidney, is reversed by acute administration of recombinant soluble RAGE. In other tissues, e.g., intestine, skin, both recombinant soluble RAGE and control protein had some effects (Figure 11B). TBIR results in diabetic rats were not as clear as those for normal rats. This is believed to be a result of diabetes associated changes in hemodynamic factors that may effect TBIR. Accordingly, additional assays were

performed to confirm the efficacy of RAGE in preventing diabetes associated increases in permeability.

C. Albumin Clearance Studies in STZ-induced Diabetic Rats

5

Young adult Spargue-Dawley rats (male, 6 weeks old, 150 g) were used. Diabetes was again induced by intravenous injection of streptozocin (65 mg/kg, available from Sigma Chemical Co.). Urine output and animal weight were monitored and blood samples collected weekly (tail clip sampling) for determination of serum glucose concentrations (glucose oxidase method). Animals rendered diabetic ([glucose]> 30mM) were used for experimental protocols. Rats were anesthetized with isoflurane (1.5-2%) in the day of the experiment. Cannulae were placed in the jugular veins and left carotid artery. Five percent BSA (6 mg/Kg) was administered to compensate for fluid and protein losses during surgery. The animals were allowed to stabilize for 20-30 minutes prior to treatment.

For animals that received recombinant proteins, the following additional treatments were performed prior to infusion of a tracer: Recombinant soluble RAGE purified according to the methods described above was administered at infusion rates to achieve plasma concentrations of 60-80 µg/ml for 1.5 hours. Arterial pressure, right atrial pressure, and body temperature were continuously monitored. Western blotting was performed on plasma samples and standards to determine the level of circulating recombinant protein during the studies.

Albumin extravasation (albumin clearance,  $C_{RSA}$ ) into individual tissues was calculated as the difference between the 35 minute  $^{131}\text{I}$ -RSA (rat serum albumin)(injected at  $t=0$ ) and 5 minute  $^{125}\text{I}$ -RSA (injected at  $t=30$  minutes) distribution volumes (See Figure 12). A 30 minute clearance period was chosen in order to minimize loss of extravasated tracer from high permeability tissues (i.e., gut, kidney). Twenty tissue samples were surveyed in the studies: skin (hindlimb and back); skeletal muscle (gastrocnemius, tibialis anterior, abdominal wall); heart (left ventricle); lung (right and lefty lower lobe); lower trachea; aorta, sciatic nerve; retina; kidney; pancreas, jejunum, ileum, colon, testis, cerebrum and visceral fat pad. Initial and final plasma volumes were estimated as the 5 minutes  $^{131}\text{I}$ -RSA and  $^{125}\text{I}$ -RSA distribution volumes, respectively. Tissue extravascular water contents (EVW) were determined as (wet weight)-(  $^{125}\text{I}$ -RSA volume)-(dry weight). Values of  $C_{RSA}$  and EVW were normalized to tissue blood-free dry weight. The data were separated into early (2-3 weeks), mid (4-10 weeks), and late (11-20 weeks) phases following streptozocin injection for comparison.

Regression analysis was performed on individual values of  $C_{RSA}$  (over 30 minutes) plotted as a function of paired values of EVW. The slope of this

relationship approximates the ratio of filtrate to plasma albumin concentration (i.e., the solvent drag coefficient). For hindlimb skin and skeletal muscles, the regression analyses were performed on differences in  $C_{RSA}$  and EVW between paired hindlimbs (congested vs. non-congested). The results are shown in Figures 13A (early), 13B (mid) and 13C (late).

Over the 20 week "post-STZ treatment" period, there were increases in albumin clearance in visceral fat (+385%) in the early phase, and in skin (+75%), skeletal muscle (+68%) aorta (80%) and trachea (+84%) in the late phase. No differences in albumin clearance were apparant in intestine, kidney and heart tissue of diabetic rats compared with that of control rats. An intravenous administration of recombinant soluble RAGE (1 mg/Kg body weight) 1 hour prior to the clearance measurement shows some effect on reducing albumin clearance rates in visceral fat in early phase diabetes. Similar results were obtained for tissue extravascular water content per gram of dry weight (Figures 14A-C). Although not shown there were also indications that recombinant soluble RAGE reduced capillary pressure in diabetic rats.

#### D. Single Microvessel Studies

Normal rats were anesthetized with 1% and the ileal mesentary was exposed through a midline incision. The exposed gut was continuously superfused with mammalian Ringer's solution. Experiments were performed by cannulating a test vessel with control solution (5 mg/ml BSA and washed RBCs from normal rats or from diabetic rats in Ringer's solution) in the absence or presence of recombinant soluble RAGE, and examining the vessel for sticking red blood cells under a microscope. Examples of these vessels are shown in Figures 15A and 15B. Diabetic RBCs adhered to the venular wall when perfused into a normal rat vessel, whereas normal RBCs did not. Subsequent perfusion of diabetic RBCs and recombinant soluble RAGE into the same vessel did not result in further sticking of diabetic RBCs to the vessel wall. Perfusion of diabetic RBCs pretreated with recombinant soluble RAGE into the vessel from the same animal used previously did not result in adherence of RBCs to the vessel wall. Subsequent perfusion of diabetic RBCs (not pretreated with RAGE) did not result in adherence of the RBCs to the vessel wall.

While the foregoing invention has been described in some detail for purposes of clarity and understanding, it will be clear to one skilled in the art from a reading of this disclosure that various changes in form and detail can be made without departing from the true scope of the invention. All publications and patent documents cited in this application are incorporated by reference in their entirety for

all purposes to the same extent as if each individual publication or patent document were so individually denoted.



## SEQUENCE LISTING

## INFORMATION FOR SEQ ID NO:1:

## 5 (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 1023 base pairs

(B) TYPE: nucleic acid

(C) STRANDEDNESS: double

(D) TOPOLOGY: linear

10

## (ii) MOLECULE TYPE: DNA (genomic)

15

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

ATGGCAGCCG	GAACAGCAGT	TGGAGCCTGG	GTGCTGGTCC	TCAGTCTGTG	GGGGGCAGTA	60
GTAGGTGCTC	AAAACATCAC	AGCCCGGATT	GGCGAGCCAC	TGGTGCTGAA	GTGTAAGGGG	120
GCCCCAAGA	AACCACCCCA	GCGGCTGGAA	TGGAACTGA	ACACAGGCCG	GACAGAAGCT	180
TGGAAGGTCC	TGTCTCCCCA	GGGAGGAGGC	CCCTGGGACA	GTGTGGCTCG	TGTCCTTCCC	240
AACGGCTCCC	TCTTCCTTCC	GGCTGTCGGG	ATCCAGGATG	AGGGGATTTT	CCGGTGCCAG	300
GCAATGAACA	GGAATGGAAA	GGAGACCAAG	TCCAACCTACC	GAGTCCGTGT	CTACCAGATT	360
CCTGGGAAGC	CAGAAATTGT	AGATTCTGCC	TCTGAACTCA	CGGCTGGTGT	TCCCAATAAG	420
GTGGGGACAT	GTGTGTCAGA	GGGAAGCTAC	CCTGCAGGGA	CTCTTAGCTG	GCACTTGGAT	480
GGGAAGCCCC	TGGTGCCTAA	TGAGAAGGGA	GTATCTGTGA	AGGAACAGAC	CAGGAGACAC	540
CCTGAGACAG	GGCTCTTCAC	ACTGCAGTCG	GAGCTAATGG	TGACCCCAGC	CCGGGGAGGA	600
GATCCCCGTC	CCACCTTCTC	CTGTAGCTTC	AGCCAGGCC	TTCCCCGACA	CCGGGCCTTG	660
CGCACAGCCC	CCATCCAGCC	CCGTGTCTGG	GAGCCTGTGC	CTCTGGAGGA	GGTCCAATTG	720
GTGGTGGAGC	CAGAAGGTGG	AGCAGTAGCT	CCTGGTGGAA	CCGTAACCCT	GACCTGTGAA	780
GTCCCTGCCC	AGCCCTCTCC	TCAAATCCAC	TGGATGAAGG	ATGGTGTGCC	CTTGCCCCTT	840
CCCCCAGCC	CTGTGCTGAT	CCTCCCTGAG	ATAGGGCCTC	AGGACCAGGG	AACCTACAGC	900
TGTGTGGCCA	CCCATTCCAG	CCACGGGCCC	CAGGAAAGCC	GTGCTGTCAG	CATCAGCATC	960
ATCGAACCAG	GCGAGGAGGG	GCCAACTGCA	GGCTCTGTGG	GAGGATCAGG	GCTGGGAACT	1020
TGA						1023

55

## INFORMATION FOR SEQ ID NO:2:

## (i) SEQUENCE CHARACTERISTICS:

- 5 (A) LENGTH: 340 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

10

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

15

Met Ala Ala Gly Thr Ala Val Gly Ala Trp Val Leu Val Leu Ser Leu  
 1 5 10 15

20

Trp Gly Ala Val Val Gly Ala Gln Asn Ile Thr Ala Arg Ile Gly Glu  
 20 25 30

Pro Leu Val Leu Lys Cys Lys Gly Ala Pro Lys Lys Pro Pro Gln Arg  
 35 40 45

25

Leu Glu Trp Lys Leu Asn Thr Gly Arg Thr Glu Ala Trp Lys Val Leu  
 50 55 60

Ser Pro Gln Gly Gly Gly Pro Trp Asp Ser Val Ala Arg Val Leu Pro  
 65 70 75 80

30

Asn Gly Ser Leu Phe Leu Pro Ala Val Gly Ile Gln Asp Glu Gly Ile  
 85 90 95

Phe Arg Cys Gln Ala Met Asn Arg Asn Gly Lys Glu Thr Lys Ser Asn  
 100 105 110

35

Tyr Arg Val Arg Val Tyr Gln Ile Pro Gly Lys Pro Glu Ile Val Asp  
 115 120 125

Ser Ala Ser Glu Leu Thr Ala Gly Val Pro Asn Lys Val Gly Thr Cys  
 130 135 140

40

Val Ser Glu Gly Ser Tyr Pro Ala Gly Thr Leu Ser Trp His Leu Asp  
 145 150 155 160

45

Gly Lys Pro Leu Val Pro Asn Glu Lys Gly Val Ser Val Lys Glu Gln  
 165 170 175

Thr Arg Arg His Pro Glu Thr Gly Leu Phe Thr Leu Gln Ser Glu Leu  
 180 185 190

50

Met Val Thr Pro Ala Arg Gly Gly Asp Pro Arg Pro Thr Phe Ser Cys  
 195 200 205

55

41

Ser Phe Ser Pro Gly Leu Pro Arg His Arg Ala Leu Arg Thr Ala Pro  
 210 215 220  
 5 Ile Gln Pro Arg Val Trp Glu Pro Val Pro Leu Glu Glu Val Gln Leu  
 225 230 235 240  
 Val Val Glu Pro Glu Gly Gly Ala Val Ala Pro Gly Gly Thr Val Thr  
 245 250 255  
 10 Leu Thr Cys Glu Val Pro Ala Gln Pro Ser Pro Gln Ile His Trp Met  
 260 265 270  
 Lys Asp Gly Val Pro Leu Pro Leu Pro Pro Ser Pro Val Leu Ile Leu  
 275 280 285  
 15 Pro Glu Ile Gly Pro Gln Asp Gln Gly Thr Tyr Ser Cys Val Ala Thr  
 290 295 300  
 20 His Ser Ser His Gly Pro Gln Glu Ser Arg Ala Val Ser Ile Ser Ile  
 305 310 315 320  
 Ile Glu Pro Gly Glu Glu Gly Pro Thr Ala Gly Ser Val Gly Gly Ser  
 325 330 335  
 25 Gly Leu Gly Thr  
 340

## 30 INFORMATION FOR SEQ ID NO:3:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 957 base pairs  
 (B) TYPE: nucleic acid  
 35 (C) STRANDEDNESS: double  
 (D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: DNA (genomic)

40

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

45 GCTCAAAACA TCACAGCCCG GATTGGCGAG CCACTGGTGC TGAAGTGTA GGGGGCCCCC 60  
 AAGAAACCAC CCCAGCGGCT GGAATGGAAA CTGAACACAG GCCGGACAGA AGCTTGGAAG 120  
 50 GTCCTGTCTC CCCAGGGAGG AGGCCCTGG GACAGTGTGG CTCGTGTCCT TCCCAACGGC 180  
 TCCCTCTTCC TTCCCCCTGT CGGGATCCAG GATGAGGGGA TTTCCGGTG CCAGGCAATG 240  
 AACAGGAATG GAAAGGAGAC CAAGTCCAAC TACCGAGTCC GTGTCTACCA GATTCCTGGG 300  
 55 AAGCCAGAAA TTGTAGATTC TGCCTCTGAA CTCACGGCTG GTGTTCCCAA TAAGGTGGGG 360

ACATGTGTGT CAGAGGGAAG CTACCCTGCA GGGACTCTTA GCTGGCACTT GGATGGGAAG 420  
 CCCCTGGTGC CTAATGAGAA GGGAGTATCT GTGAAGGAAC AGACCAGGAG ACACCCTGAG 480  
 5 ACAGGGCTCT TCACACTGCA GTCGGAGCTA ATGGTGACCC CAGCCCGGGG AGGAGATCCC 540  
 CGTCCCACCT TCTCCTGTAG CTTCAGCCCA GGCCTTCCCC GACACCGGGC CTTGCGCACA 600  
 10 GCCCCATCC AGCCCCGTGT CTGGGAGCCT GTGCCTCTGG AGGAGGTCCA ATTGGTGGTG 660  
 GAGCCAGAAG GTGGAGCAGT AGCTCCTGGT GGAACCGTAA CCCTGACCTG TGAAGTCCCT 720  
 GCCCAGCCCT CTCCTCAAAT CCACTGGATG AAGGATGGTG TGCCCTTGCC CCTTCCCCCC 780  
 15 AGCCCTGTGC TGATCCTCCC TGAGATAGGG CCTCAGGACC AGGGAACCTA CAGCTGTGTG 840  
 GCCACCCATT CCAGCCACGG GCCCCAGGAA AGCCGTGCTG TCAGCATCAG CATCATCGAA 900  
 20 CCAGGCGAGG AGGGGCCAAC TGCAGGCTCT GTGGGAGGAT CAGGGCTGGG AACTTGA 957

# INFORMATION FOR SEQ ID NO:4:

25

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 318 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: single

30

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

35

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

Ala Gln Asn Ile Thr Ala Arg Ile Gly Glu Pro Leu Val Leu Lys Cys  
 1 5 10 15  
 Lys Gly Ala Pro Lys Lys Pro Pro Gln Arg Leu Glu Trp Lys Leu Asn  
 20 25 30  
 45 Thr Gly Arg Thr Glu Ala Trp Lys Val Leu Ser Pro Gln Gly Gly Gly  
 35 40 45  
 Pro Trp Asp Ser Val Ala Arg Val Leu Pro Asn Gly Ser Leu Phe Leu  
 50 55 60  
 Pro Ala Val Gly Ile Gln Asp Glu Gly Ile Phe Arg Cys Gln Ala Met  
 65 70 75 80  
 55 Asn Arg Asn Gly Lys Glu Thr Lys Ser Asn Tyr Arg Val Arg Val Tyr  
 85 90 95

	Gln	Ile	Pro	Gly	Lys	Pro	Glu	Ile	Val	Asp	Ser	Ala	Ser	Glu	Leu	Thr			
							100			105					110				
5	Ala	Gly	Val	Pro	Asn	Lys	Val	Gly	Thr	Cys	Val	Ser	Glu	Gly	Ser	Tyr			
			115					120					125						
	Pro	Ala	Gly	Thr	Leu	Ser	Trp	His	Leu	Asp	Gly	Lys	Pro	Leu	Val	Pro			
10		130					135					140							
	Asn	Glu	Lys	Gly	Val	Ser	Val	Lys	Glu	Gln	Thr	Arg	Arg	His	Pro	Glu			
	145					150				155					160				
	Thr	Gly	Leu	Phe	Thr	Leu	Gln	Ser	Glu	Leu	Met	Val	Thr	Pro	Ala	Arg			
15					165					170					175				
	Gly	Gly	Asp	Pro	Arg	Pro	Thr	Phe	Ser	Cys	Ser	Phe	Ser	Pro	Gly	Leu			
				180					185					190					
20	Pro	Arg	His	Arg	Ala	Leu	Arg	Thr	Ala	Pro	Ile	Gln	Pro	Arg	Val	Trp			
		195						200					205						
	Glu	Pro	Val	Pro	Leu	Glu	Glu	Val	Gln	Leu	Val	Val	Glu	Pro	Glu	Gly			
25		210					215					220							
	Gly	Ala	Val	Ala	Pro	Gly	Gly	Thr	Val	Thr	Leu	Thr	Cys	Glu	Val	Pro			
	225					230					235					240			
	Ala	Gln	Pro	Ser	Pro	Gln	Ile	His	Trp	Met	Lys	Asp	Gly	Val	Pro	Leu			
30					245					250					255				
	Pro	Leu	Pro	Pro	Ser	Pro	Val	Leu	Ile	Leu	Pro	Glu	Ile	Gly	Pro	Gln			
			260					265						270					
35	Asp	Gln	Gly	Thr	Tyr	Ser	Cys	Val	Ala	Thr	His	Ser	Ser	His	Gly	Pro			
		275						280					285						
	Gln	Glu	Ser	Arg	Ala	Val	Ser	Ile	Ser	Ile	Ile	Glu	Pro	Gly	Glu	Glu			
40		290					295					300							
	Gly	Pro	Thr	Ala	Gly	Ser	Val	Gly	Gly	Ser	Gly	Leu	Gly	Thr					
	305					310					315								

INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 10 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

55

44

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

Cys Lys Gly Ala Pro Lys Lys Pro Pro Gln  
1 5 10

5

## INFORMATION FOR SEQ ID NO:6:

10

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 11 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: single

15

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

20

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

Trp Lys Leu Asn Thr Gly Arg Thr Glu Ala Cys  
1 5 10

25

30

## INFORMATION FOR SEQ ID NO:7:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

35

## (ii) MOLECULE TYPE: peptide

40

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

Gly Pro Gln Asp Gln Gly Thr Tyr Ser Cys  
1 5 10

45

50

45

## INFORMATION FOR SEQ ID NO:8:

## (i) SEQUENCE CHARACTERISTICS:

- 5 (A) LENGTH: 10 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

10

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

15

Trp Lys Leu Asn Thr Gly Arg Thr Glu Ala  
1 5 10

20

## INFORMATION FOR SEQ ID NO:9:

## (i) SEQUENCE CHARACTERISTICS:

- 25 (A) LENGTH: 11 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

30

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

35

Cys Glu Val Pro Ala Gln Pro Ser Pro Gln Ile  
1 5 10

40

## INFORMATION FOR SEQ ID NO:10:

## (i) SEQUENCE CHARACTERISTICS:

45

- (A) LENGTH: 14 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

50

46

(ii) MOLECULE TYPE: peptide

5

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

10 Cys Arg Ala Met Asn Gln Asn Gly Lys Glu Thr Lys Ser Asn  
1 5 10

INFORMATION FOR SEQ ID NO:11:

15

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: single

20 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

25

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

30 Gly Pro Gln Asp Gln Gly Thr Tyr Ser Cys  
1 5 10

35 INFORMATION FOR SEQ ID NO:12:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 15 amino acids

(B) TYPE: amino acid

40 (C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

45

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

50 Ala Gln Asn Ile Thr Ala Arg Ile Gly Glu Pro Leu Val Leu Lys  
1 5 10 15



47

## INFORMATION FOR SEQ ID NO:13:

- 5 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 10 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

- 10 (ii) MOLECULE TYPE: peptide

- 15 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

Cys Lys Gly Ala Pro Lys Lys Pro Pro Gln  
1 5 10

20

## INFORMATION FOR SEQ ID NO:14:

- 25 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 9 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

- 30 (ii) MOLECULE TYPE: peptide

- 35 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

Glu Gln Thr Arg Arg His Pro Glu Thr  
1 5

40

## INFORMATION FOR SEQ ID NO:15:

- 45 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 11 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

50

- (ii) MOLECULE TYPE: peptide

48

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

5           Arg Gly Gly Asp Pro Arg Pro Thr Phe Ser Cys  
          1                           5                           10

10 INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: single

15 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

20

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:

25           Ser Pro Gly Leu Pro Arg His Arg Ala Leu  
          1                           5                           10

30 INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

35 (C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

40

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

45           Ser Ser His Gly Pro Gln Glu Ser Arg Ala  
          1                           5                           10

50

## INFORMATION FOR SEQ ID NO:18:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 16 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:18:

Ala Gln Asn Ile Thr Ala Arg Ile Gly Glu Pro Leu Val Leu Lys Cys  
1 5 10 15

## INFORMATION FOR SEQ ID NO:19:

## (i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 10 amino acids

(B) TYPE: amino acid

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

Cys Glu Gln Thr Arg Arg His Pro Glu Thr  
1 5 10

50

## INFORMATION FOR SEQ ID NO:20:

## (i) SEQUENCE CHARACTERISTICS:

- 5 (A) LENGTH: 11 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

10

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

15

Cys Ser Pro Gly Leu Pro Arg His Arg Ala Leu  
1 5 10

20

## INFORMATION FOR SEQ ID NO:21:

## (i) SEQUENCE CHARACTERISTICS:

- 25 (A) LENGTH: 11 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

## (ii) MOLECULE TYPE: peptide

30

## (xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

35

Ser Ser His Gly Pro Gln Glu Ser Arg Ala Cys  
1 5 10

40

45

50

## INFORMATION FOR SEQ ID NO:22:

- 5 (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 22 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

10

(ii) MOLECULE TYPE: DNA (genomic)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:

15 GATGGCAGCC GGAACAGCAG TT

22

## 20 INFORMATION FOR SEQ ID NO:23:

- (i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 24 base pairs  
(B) TYPE: nucleic acid  
25 (C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

30

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:

35 CTCAAGTTCC CAGCCCTGAT CCTC

24



# American Type Culture Collection

12301 Parklawn Drive • Rockville, MD 20852 USA • Telephone: (301) 231-5520 Telex: 903-768 ATCCROVE • FAX: 301-816-4344

BUDAPEST TREATY ON THE INTERNATIONAL RECOGNITION OF  
THE DEPOSIT OF MICROORGANISMS FOR THE PURPOSES OF PATENT PROCEDURE  
*INTERNATIONAL FORM*  
RECEIPT IN THE CASE OF AN ORIGINAL DEPOSIT ISSUED PURSUANT TO RULE 7.3  
AND VIABILITY STATEMENT ISSUED PURSUANT TO RULE 10.2

To: (Name and Address of Depositor or Attorney)

Berlex Biosciences  
Attn: Mariko Nagashima  
15049 San Pablo Avenue  
Richmond, CA 94804

Deposited on Behalf of: Berlex Biosciences, a division of Berlex Laboratories, Inc.

Identification Reference by Depositor:

ATCC Designation

AcMNPV Baculovirus RAGE 23-1  
AcMNPV Baculovirus RAGE 11B

VR-2538  
VR-2539

The deposits were accompanied by: ☐ a scientific description ☐ a proposed taxonomic description indicated above.

The deposits were received July 10, 1996 by this International Depository Authority and have been accepted.

AT YOUR REQUEST:

☒ We will inform you of requests for the strains for 30 years.

The strains will be made available if a patent office signatory to the Budapest Treaty certifies one's right to receive, or if a U.S. Patent is issued citing the strains, and ATCC is instructed by the United States Patent & Trademark Office or the depositor to release said strains.

If the cultures should die or be destroyed during the effective term of the deposit, it shall be your responsibility to replace them with living cultures of the same.

The strains will be maintained for a period of at least 30 years from date of deposit, or five years after the most recent request for a sample, whichever is longer. The United States and many other countries are signatory to the Budapest Treaty.

The viability of the cultures cited above was tested July 29, 1996. On that date, the cultures were viable.

International Depository Authority: American Type Culture Collection, Rockville, Md. 20852 USA

Signature of person having authority to represent ATCC:

Barbara M. Hailey

Barbara M. Hailey, Administrator, Patent Depository

Date: August 6, 1996

✓cc: Carol J. Roth



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# American Type Culture Collection

12301 Parklawn Drive • Rockville, MD 20852 USA • Telephone: (301)231-5520 Telex: 908-768 ATCCROVE • FAX: 301-816-4366

BUDAPEST TREATY ON THE INTERNATIONAL RECOGNITION OF  
THE DEPOSIT OF MICROORGANISMS FOR THE PURPOSES OF PATENT PROCEDURE

## INTERNATIONAL FORM

RECEIPT IN THE CASE OF AN ORIGINAL DEPOSIT ISSUED PURSUANT TO RULE 7.3  
AND VIABILITY STATEMENT ISSUED PURSUANT TO RULE 10.2

To: (Name and Address of Depositor or Attorney)

Berlex Biosciences  
Attn: Doris A. Hollander  
15049 San Pablo Avenue  
Richmond, CA 94804-0099

Deposited on Behalf of: Berlex Biosciences

Identification Reference by Depositor:

ATCC Designation

Hybridoma cell line, mouse x mouse, SW 10C1  
Hybridoma cell line, mouse x mouse, RBF 9D9  
Hybridoma cell line, mouse x mouse, SW1E8

HB-12164  
HB-12165  
HB-12166

The deposits were accompanied by: ☐ a scientific description ☐ a proposed taxonomic description indicated above.

The deposits were received August 6, 1996 by this International Depository Authority and have been accepted.

AT YOUR REQUEST:

☒ We will inform you of requests for the strains for 30 years.

The strains will be made available if a patent office signatory to the Budapest Treaty certifies one's right to receive, or if a U.S. Patent is issued citing the strains, and ATCC is instructed by the United States Patent & Trademark Office or the depositor to release said strains.

If the cultures should die or be destroyed during the effective term of the deposit, it shall be your responsibility to replace them with living cultures of the same.

The strains will be maintained for a period of at least 30 years from date of deposit, or five years after the most recent request for a sample, whichever is longer. The United States and many other countries are signatory to the Budapest Treaty.

The viability of the cultures cited above was tested August 9, 1996. On that date, the cultures were viable.

International Depository Authority: American Type Culture Collection, Rockville, Md. 20852 USA

Signature of person having authority to represent ATCC:

Barbara M. Hailey  
Barbara M. Hailey, Administrator, Patent Depository

Date: August 9, 1996

✓cc: Carol J. Roth

## Claims

54

1. An isolated antibody, said antibody being specifically  
5 immunoreactive with a soluble human receptor to an advanced glycosylation end-product ("RAGE") polypeptide.
2. The isolated antibody of claim 1, wherein said antibody is  
specifically immunoreactive with a polypeptide having an amino acid sequence  
10 substantially homologous to the amino acid sequence shown in Figures 1A or 1B (Seq ID NOS: 2 and 4), or immunologically active fragments thereof.
3. The isolated antibody of claim 2, wherein said antibody is  
specifically immunoreactive with a polypeptide having an amino acid sequence  
15 shown in Figure 1B (Seq ID NO: 4).
4. The isolated antibody of claim 1, wherein said antibody is  
monoclonal.
- 20 5. The isolated antibody of claim 1, wherein said antibody is selected from the group consisting of RBF9D9 (ATCC Accession No. HB-12165), SW10C1 (ATCC Accession No. HB-12164) and SW1E8 (ATCC Accession No. HB-12166).
- 25 6. The isolated antibody of claim 1, wherein said antibody is polyclonal.
7. The isolated antibody of claim 1, wherein said antibody is  
humanized.  
30
8. The isolated antibody of claim 1, wherein said antibody further  
comprises a labeling group.
9. The isolated antibody of claim 8, wherein said labeling group is  
35 selected from the group consisting of a fluorescent label, a radioactive label and a bioactive label.



10. An isolated antibody, said antibody being capable of inhibiting an interaction between an advanced glycosylation end-product ("AGE") and its receptor.

5 11. The isolated antibody of claim 10, wherein said antibody is specifically immunoreactive with a soluble human RAGE polypeptide.

12. The isolated antibody of claim 11, wherein said human RAGE polypeptide is a soluble human RAGE polypeptide having an amino acid sequence shown in Figure 1A or 1B (Seq ID NOS: 2 and 4), or immunologically active fragments thereof.

13. A pharmaceutical composition, comprising an antibody that is specifically immunoreactive with a soluble human RAGE polypeptide in combination with a pharmaceutically acceptable carrier.

14. The pharmaceutical composition of claim 13, wherein said antibody inhibits an interaction between an AGE protein and a human RAGE polypeptide.

15. The pharmaceutical composition of claim 13, wherein said antibody is specifically immunoreactive with a polypeptide having an amino acid sequence substantially homologous to the amino acid sequence shown in Figure 1A or 1B (Seq ID NOS: 2 and 4), or immunologically active fragments thereof.

16. The pharmaceutical composition of claim 13, wherein said antibody is specifically immunoreactive with a polypeptide having an amino acid sequence substantially homologous to the amino acid sequence shown in Figure 1A or 1B (Seq ID NOS: 2 and 4).

17. A method of treating a patient for symptoms of a disorder, wherein said symptoms are caused by an interaction between an AGE and its receptor, the method comprising administering to said patient an effective amount of an antibody that is specifically immunoreactive with a soluble human RAGE polypeptide.

18. The method of claim 17, wherein said patient is a diabetic patient, and said symptom is increased vascular permeability.

19. The method of claim 17, wherein said disorder is Diabetes Mellitus and said symptom is selected from the group consisting of diabetic microvasculopathy, diabetic macrovasculopathy and occlusive vascular disorder.

5 20. The method of claim 19, wherein said symptom is selected from the group consisting of neuropathy, nephropathy, retinopathy and atherosclerosis.

21. A method of detecting a human RAGE polypeptide in a sample, the method comprising the steps of:  
10 contacting the sample with an isolated antibody that is specifically immunoreactive with a soluble human RAGE polypeptide; and  
determining whether the antibody specifically immunoreacts with a component of the sample.

15 22. A method of purifying a human RAGE polypeptide from a mixture of proteins, the method comprising the steps of:  
providing an antibody that is specifically immunoreactive with a soluble human RAGE polypeptide immobilized on a solid support;  
contacting the solid support with the mixture of proteins under  
20 conditions permitting a specific immunoreaction between the antibody and the human RAGE polypeptide from the mixture of proteins;  
removing nonspecifically bound proteins from said solid support; and  
isolating the human RAGE polypeptide from the solid support in substantially pure form.

25 23. Use of an effective amount of an antibody that is specifically immunoreactive with a soluble human RAGE polypeptide for the production of a pharmaceutical compound or composition for the treatment of a patient for symptoms of a disorder, wherein said symptoms are caused by an interaction  
30 between an AGE and its receptor.

24. Use according to claim 23, wherein said patient is a diabetic patient, and said symptom is increased vascular permeability.

35 25. Use according to claim 23, wherein said disorder is Diabetes Mellitus and said symptom is selected from the group consisting of diabetic microvasculopathy, diabetic macrovasculopathy and occlusive vascular disorder.

26. Use according to claim 25, wherein said symptom is selected from the group consisting of neuropathy, nephropathy, retinopathy and atherosclerosis.

5                    27. Use according to claim 23, wherein said symptom is hemodialysis-associated amyloidosis.

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```

1      MetAlaAlaGlyThrAlaValGlyAlaTrpValLeuValLeuSerLeuTrpGlyAlaVal
2      1 ATGGCAGCCGGAACAGCAGTTGGAGCCTGGGTGCTGGTCTCAGTCTGTGGGGGCGAGTA
3
4      ValGlyAlaGlnAsnIleThrAlaArgIleGlyGluProLeuValLeuLysCysLysGly
5      61 GTAGGTGCTCAAAACATCACAGCCCGATTGGCGAGCCACTGGTGTGAAGTGTAAGGGG
6
7      AlaProLysLysProProGlnArgLeuGluTrpLysLeuAsnThrGlyArgThrGluAla
8      121 GCCCCAAGAAACCACCCAGCGGCTGGAATGGAAGTGAACACAGGCCGACAGAAAGCT
9
10     TrpLysValLeuSerProGlnGlyGlyGlyProTrpAspSerValAlaArgValLeuPro
11     181 TGAAGGTCTGTCTCCCCAGGGAGGAGGCCCTGGGACAGTGTGGCTCGTGTCTTCCC
12
13     AsnGlySerLeuPheLeuProAlaValGlyIleGlnAspGluGlyIlePheArgCysGln
14     241 AACGGCTCCCTCTTCTTCCGGCTGTGGGATCCAGGATGAGGGGATTTCCGGTGCCAG
15
16     AlaMetAsnArgAsnGlyLysGluThrLysSerAsnTyrArgValArgValTyrGlnIle
17     301 GCAATGAACAGGAATGGAAGGAGACCAAGTCCAACCTACCGAGTCCGTGTCTACCAGATT
18
19     ProGlyLysProGluIleValAspSerAlaSerGluLeuThrAlaGlyValProAsnLys
20     361 CTGGGAAGCCAGAAATTGTAGATTCTGCCTCTGAACTCACGGCTGGTGTTCCTCAATAAG
21
22     ValGlyThrCysValSerGluGlySerTyrProAlaGlyThrLeuSerTrpHisLeuAsp
23     421 GTGGGGACATGTGTGTGTCAGAGGAAGCTACCCCTGCAGGACTCTTAGCTGGCAGTTGGAT
24
25     GlyLysProLeuValProAsnGluLysGlyValSerValLysGluGlnThrArgArgHis
26     481 GGAAGCCCTGGTGCCTAATGAGAAGGAGTATCTGTGAAGGAACAGACCAGGAGACAC
27
28     ProGluThrGlyLeuPheThrLeuGlnSerGluLeuMetValThrProAlaArgGlyGly
29     541 CCTGAGACAGGGCTCTTCACACTGCAGTCCGAGCTAATGGTGACCCAGCCCGGGGAGGA
30
31     AspProArgProThrPheSerCysSerPheSerProGlyLeuProArgHisArgAlaLeu
32     601 GATCCCGTCCCACCTTCTCTGTAGCTTCAGCCAGGCCTTCCCCGACACCGGGCCTTG
33
34     ArgThrAlaProIleGlnProArgValTrpGluProValProLeuGluGluValGlnLeu
35     661 CGCACAGCCCCATCCAGCCCCGTGTCTGGGAGCCTGTGCCTCTGGAGGAGGTCCAATTG
36
37     ValValGluProGluGlyGlyAlaValAlaProGlyGlyThrValThrLeuThrCysGlu
38     721 GTGGTGGAGCCAGAAGGTGGAGCAGTAGCTCCTGGTGGAACCGTAACCTGACCTGTGAA
39
40     ValProAlaGlnProSerProGlnIleHisTrpMetLysAspGlyValProLeuProLeu
41     781 GTCCCTGCCAGCCCTCTCCTCAATCCACTGGATGAAGGATGGTGTGCCCTTGCCCTT
42
43     ProProSerProValLeuIleLeuProGluIleGlyProGlnAspGlnGlyThrTyrSer
44     841 CCCCCAGCCCTGTGCTGATCCTCCCTGAGATAGGGCCTCAGGACCAGGGAACCTACAGC
45
46     CysValAlaThrHisSerSerHisGlyProGlnGluSerArgAlaValSerIleSerIle
47     901 TGTGTGGCCACCCATTCCAGCCACGGGCCCCAGGAAAGCCGTGCTGTGAGCATCAGCATC
48
49     IleGluProGlyGluGluGlyProThrAlaGlySerValGlyGlySerGlyLeuGlyThr
50     961 ATCGAACCAGGCGAGGAGGGGCCAACTGCAGGCTCTGTGGGAGGATCAGGGCTGGGAAT
51
52     OP
53     1021 TGA

```

Figure 1A

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1 AlaGlnAsnIleThrAlaArgIleGlyGluProLeuValLeuLysCysLysGlyAlaPro  
2 1 GCTCAAAACATCACAGCCCGGATTGGCGAGCCACTGGTGCTGAAGTGTAAAGGGGGCCCCC  
3  
4 LysLysProProGlnArgLeuGluTrpLysLeuAsnThrGlyArgThrGluAlaTrpLys  
5 61 AAGAAACCACCCAGCGGCTGGAATGGAACTGAACACAGGCCGGACAGAAGCTTGGAAAG  
6  
7 ValLeuSerProGlnGlyGlyGlyProTrpAspSerValAlaArgValLeuProAsnGly  
8 121 GTCCTGTCTCCCCAGGAGGAGGCCCTGGGACAGTGTGGCTCGTGTCTTCCCAACGGC  
9  
10 SerLeuPheLeuProAlaValGlyIleGlnAspGluGlyIlePheArgCysGlnAlaMet  
11 181 TCCCTCTTCTTCCGGCTGTCCGGATCCAGGATGAGGGGATTTCCGGTGCCAGGCAATG  
12  
13 AsnArgAsnGlyLysGluThrLysSerAsnTyrArgValArgValTyrGlnIleProGly  
14 241 AACAGGAATGGAAAGGAGACCAAGTCCAACCTACCGAGTCCGTGTCTACCAGATTCTGGG  
15  
16 LysProGluIleValAspSerAlaSerGluLeuThrAlaGlyValProAsnLysValGly  
17 301 AAGCCAGAAATTGTAGATTCTGCCTCTGAACCTCACGGCTGGTGTCCCAATAAGGTGGGG  
18  
19 ThrCysValSerGluGlySerTyrProAlaGlyThrLeuSerTrpHisLeuAspGlyLys  
20 361 ACATGTGTGTACAGGGAAGCTACCCTGCAGGGACTCTTAGCTGGCACTTGGATGGGAAG  
21  
22 ProLeuValProAsnGluLysGlyValSerValLysGluGlnThrArgArgHisProGlu  
23 421 CCCCTGGTGCCTAATGAGAAGGGAGTATCTGTGAAGGAACAGACCAGGAGACCCCTGAG  
24  
25 ThrGlyLeuPheThrLeuGlnSerGluLeuMetValThrProAlaArgGlyGlyAspPro  
26 481 ACAGGGCTCTTCACTGCAGTCCGAGCTAATGGTGACCCAGCCCGGGGAGGAGATCCC  
27  
28 ArgProThrPheSerCysSerPheSerProGlyLeuProArgHisArgAlaLeuArgThr  
29 541 CGTCCACCTTCTCCTGTAGCTTCAGCCAGGCCCTTCCCCGACACCGGGCCTTGCGCACA  
30  
31 AlaProIleGlnProArgValTrpGluProValProLeuGluGluValGlnLeuValVal  
32 601 GCCCCCATCCAGCCCCGTGTCTGGGAGCCTGTGCCTCTGGAGGAGGTCCAATTGGTGGTG  
33  
34 GluProGluGlyGlyAlaValAlaProGlyGlyThrValThrLeuThrCysGluValPro  
35 661 GAGCCAGAAGGTGGAGCAGTAGCTCCTGGTGGAACCGTAACCTGACCTGTGAAGTCCCT  
36  
37 AlaGlnProSerProGlnIleHisTrpMetLysAspGlyValProLeuProLeuProPro  
38 721 GCCCAGCCCTCTCCTCAATCCACTGGATGAAGGATGGTGTGCCCTTGCCCTTCCCCC  
39  
40 SerProValLeuIleLeuProGluIleGlyProGlnAspGlnGlyThrTyrSerCysVal  
41 781 AGCCCTGTGCTGATCCTCCCTGAGATAGGGCCTCAGGACCAGGGAACCTACAGCTGTGTG  
42  
43 AlaThrHisSerSerHisGlyProGlnGluSerArgAlaValSerIleSerIleIleGlu  
44 841 GCCACCCATTCCAGCCACGGGCCCCAGGAAAGCCGTGCTGTGAGCATCAGCATCATCGAA  
45  
46 ProGlyGluGluGlyProThrAlaGlySerValGlyGlySerGlyLeuGlyThrOP  
47 901 CCAGGCGAGGAGGGGCCAACTGCAGGCTCTGTGGGAGGATCAGGGCTGGGAACCTGA

Figure 1B

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## Indirect Solid-phase RAGE/AGE binding Assay

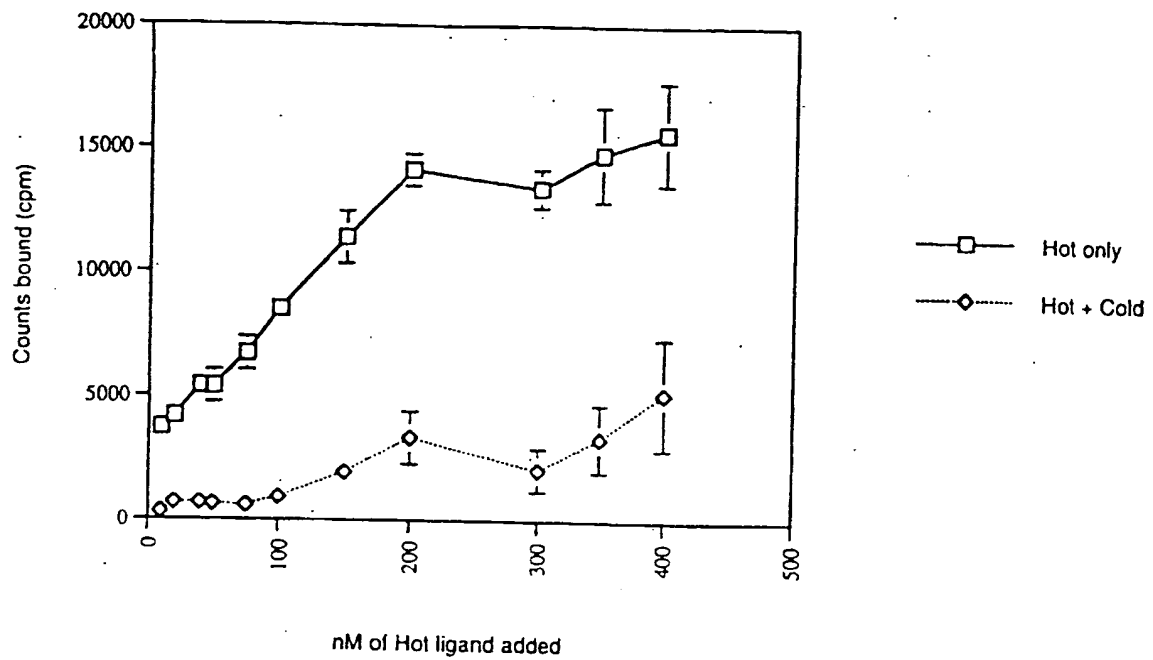


Figure 2A

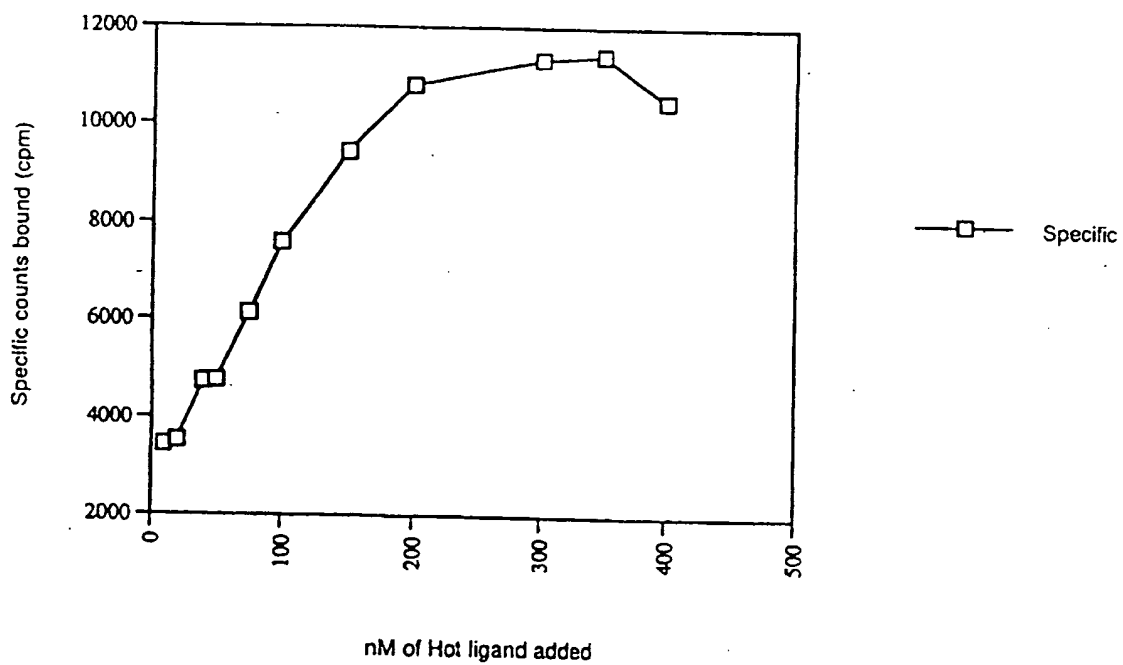


Figure 2B

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Indirect Solid-phase RAGE/AGE binding assay  
RAGE dose response curve

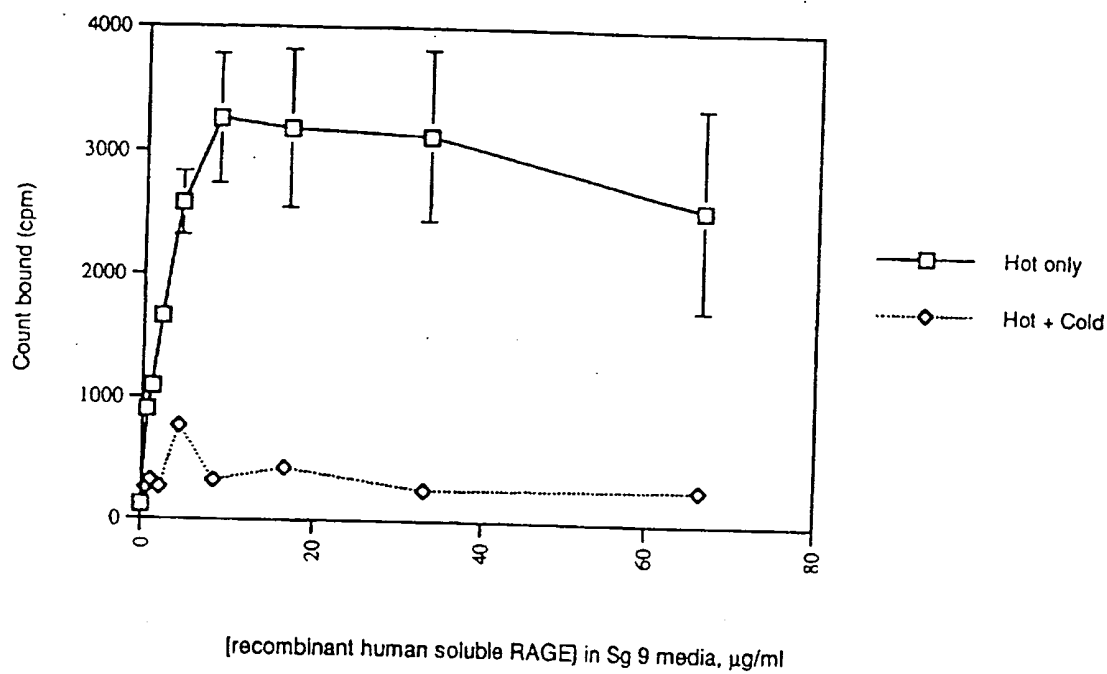
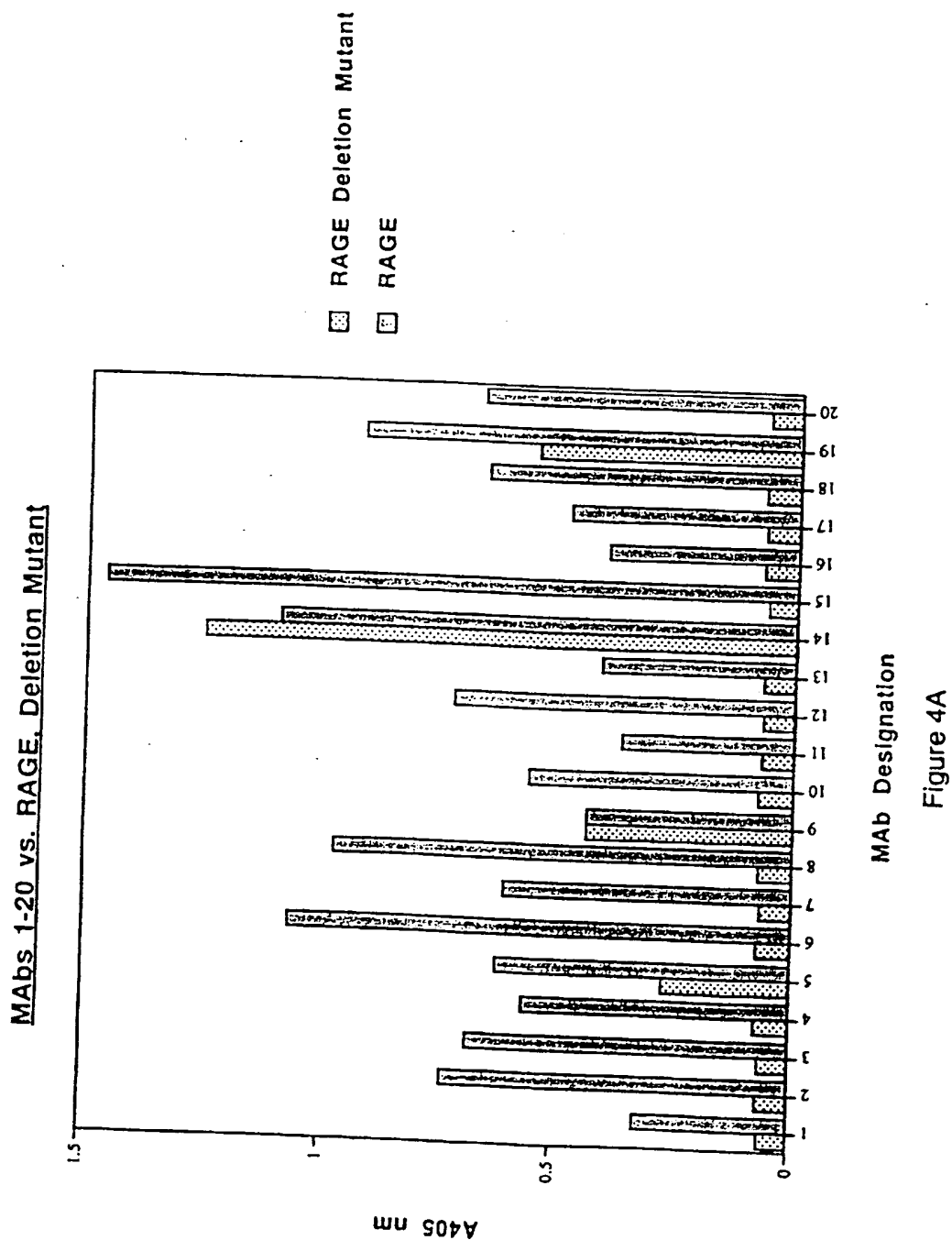


Figure 3

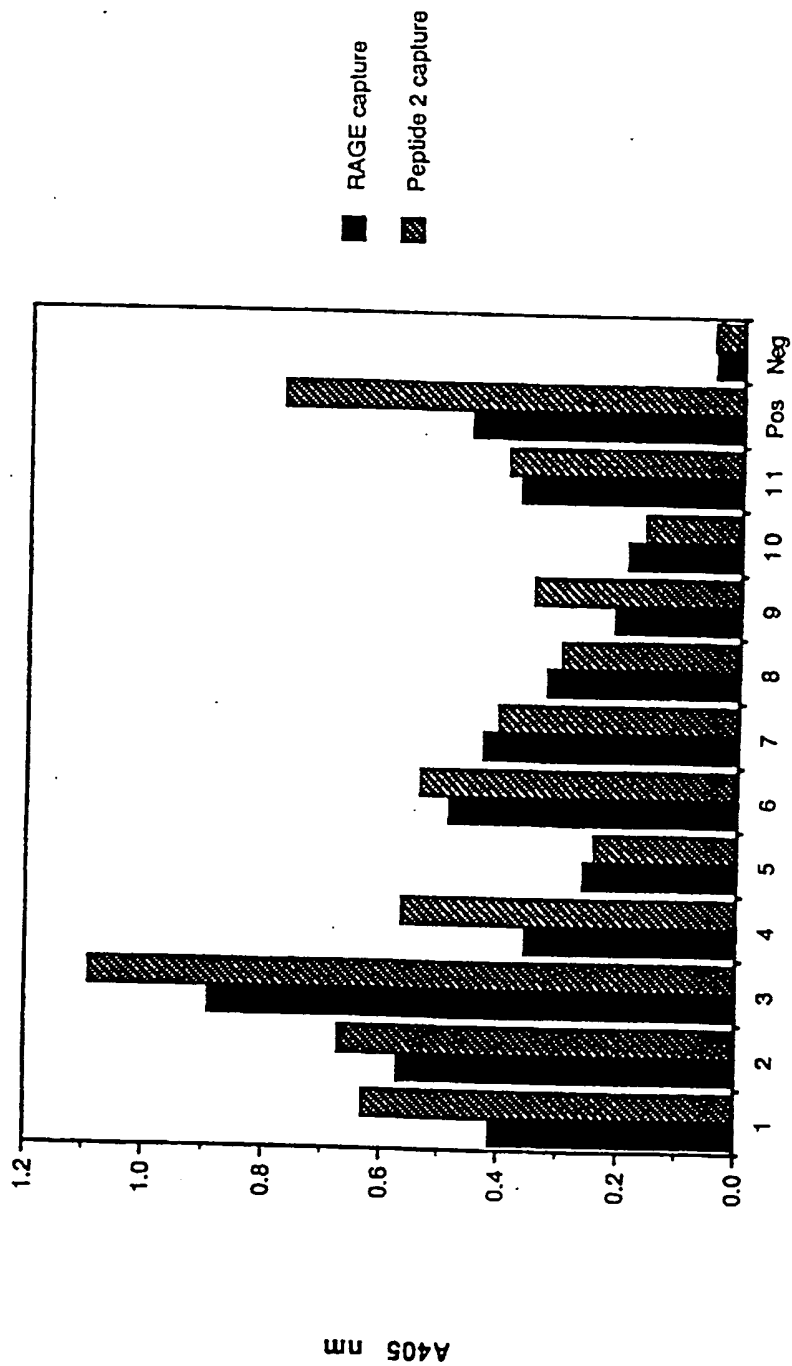
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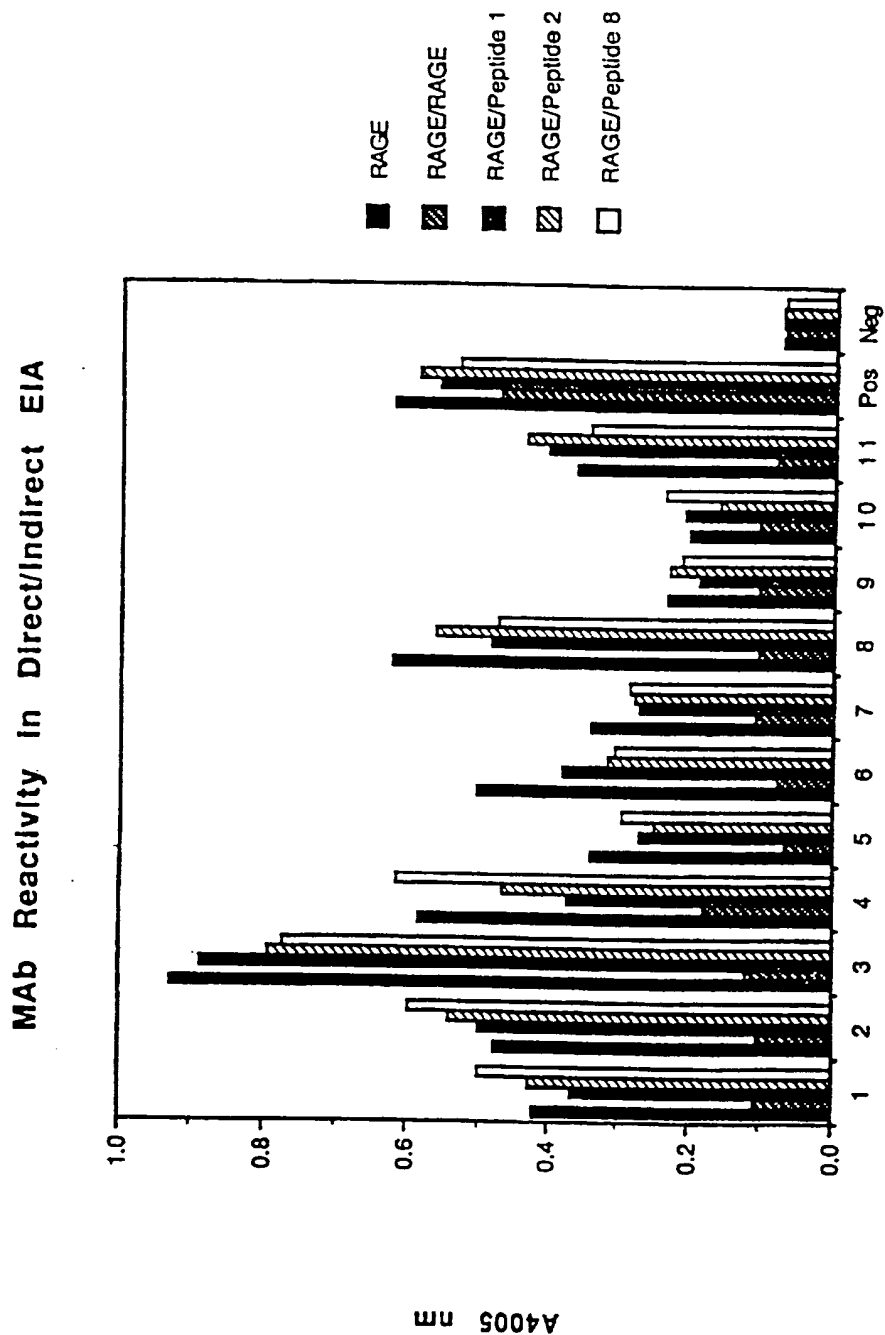
Poly/Mab Antigen Capture EIA



MAb Designation

Figure 4B

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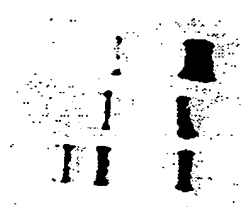


MAB Designation

Figure 4C

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1 2 3



43 kd ---

Figure 5

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## Antigen Capture EIA: MAbs 9D9:10C1

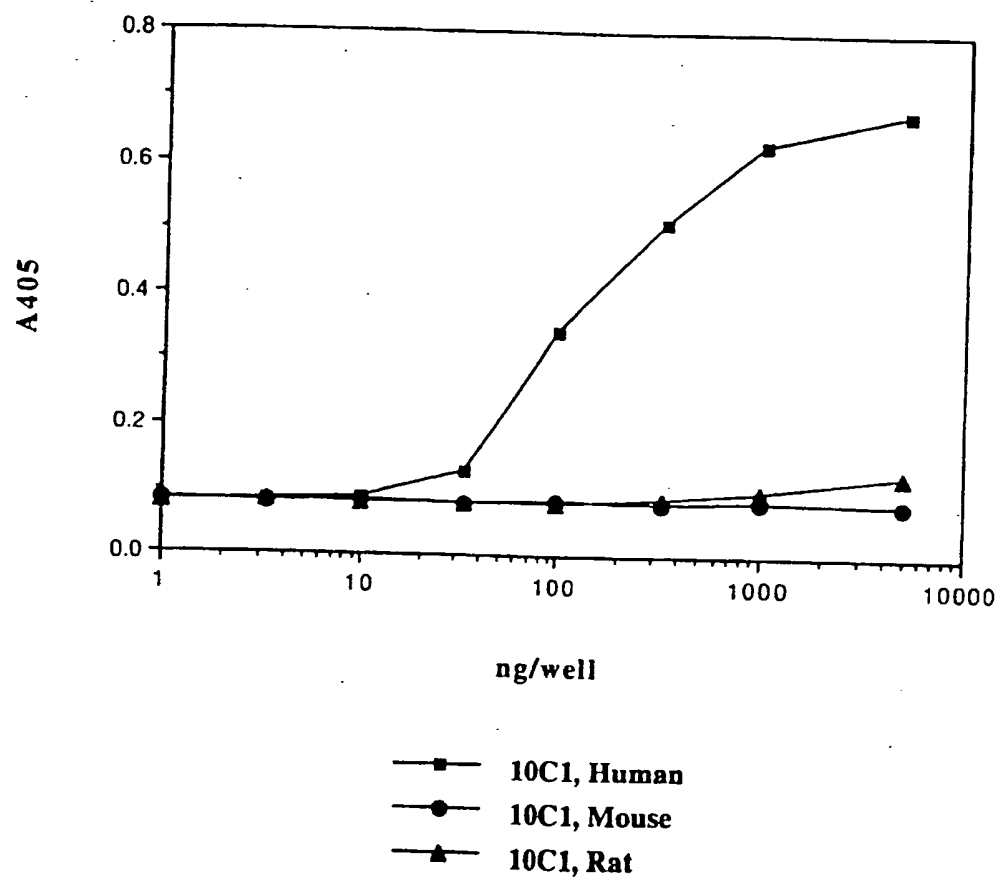


Figure 6A

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## Antigen Capture EIA: MAbs 9D9:1E8

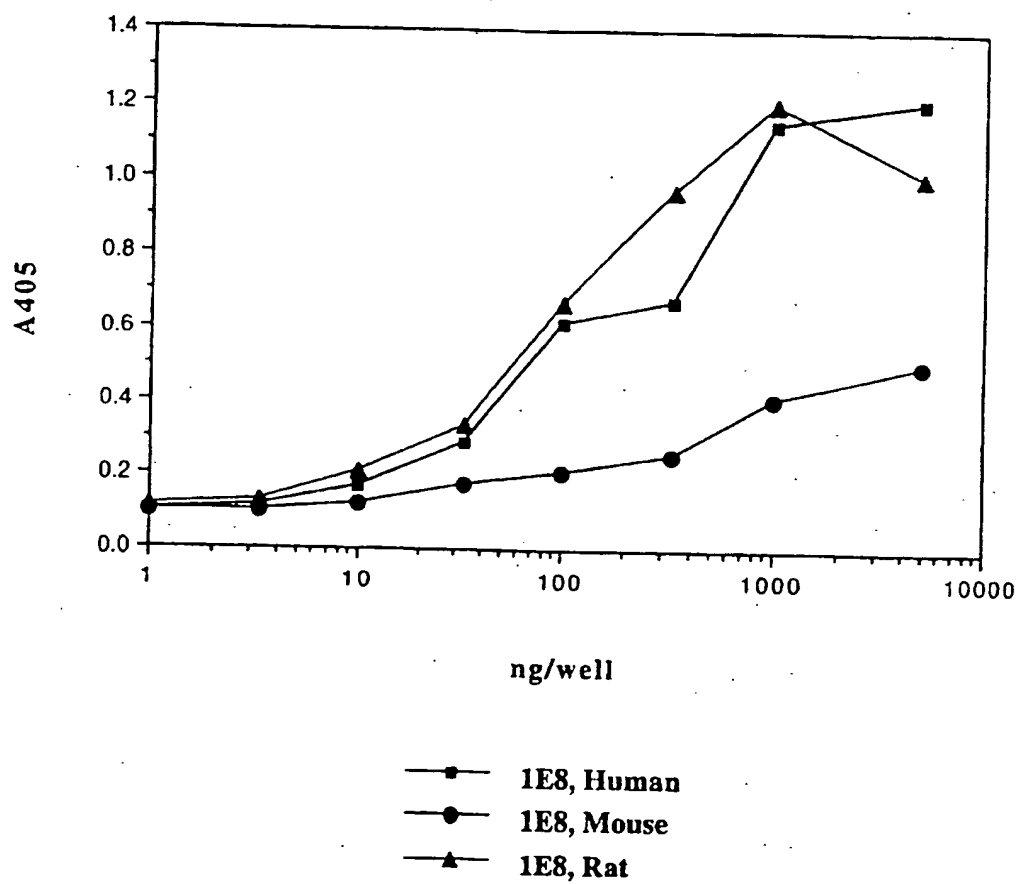


Figure 6B

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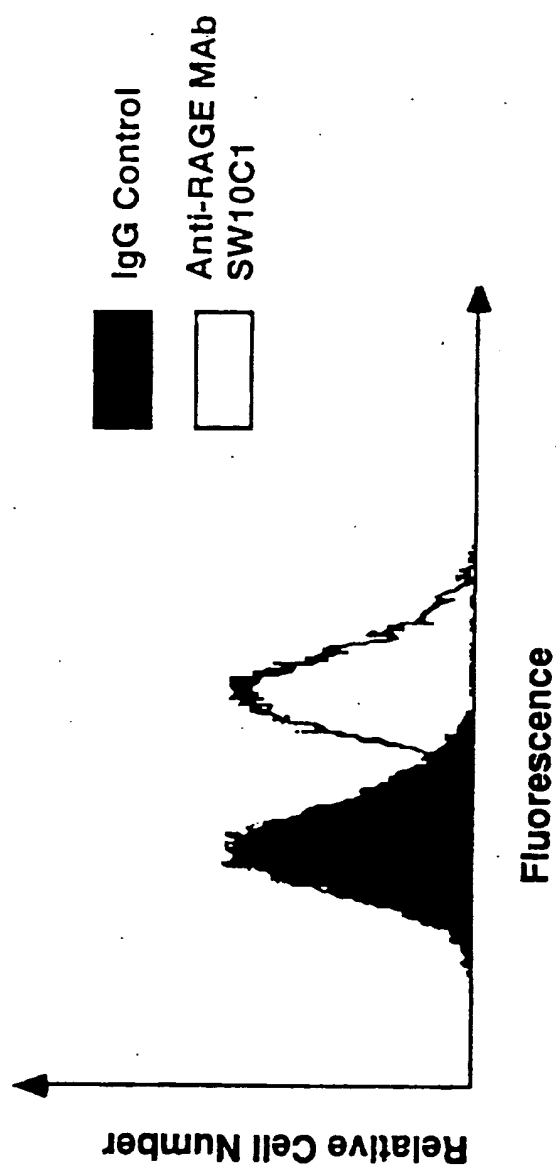


Figure 7

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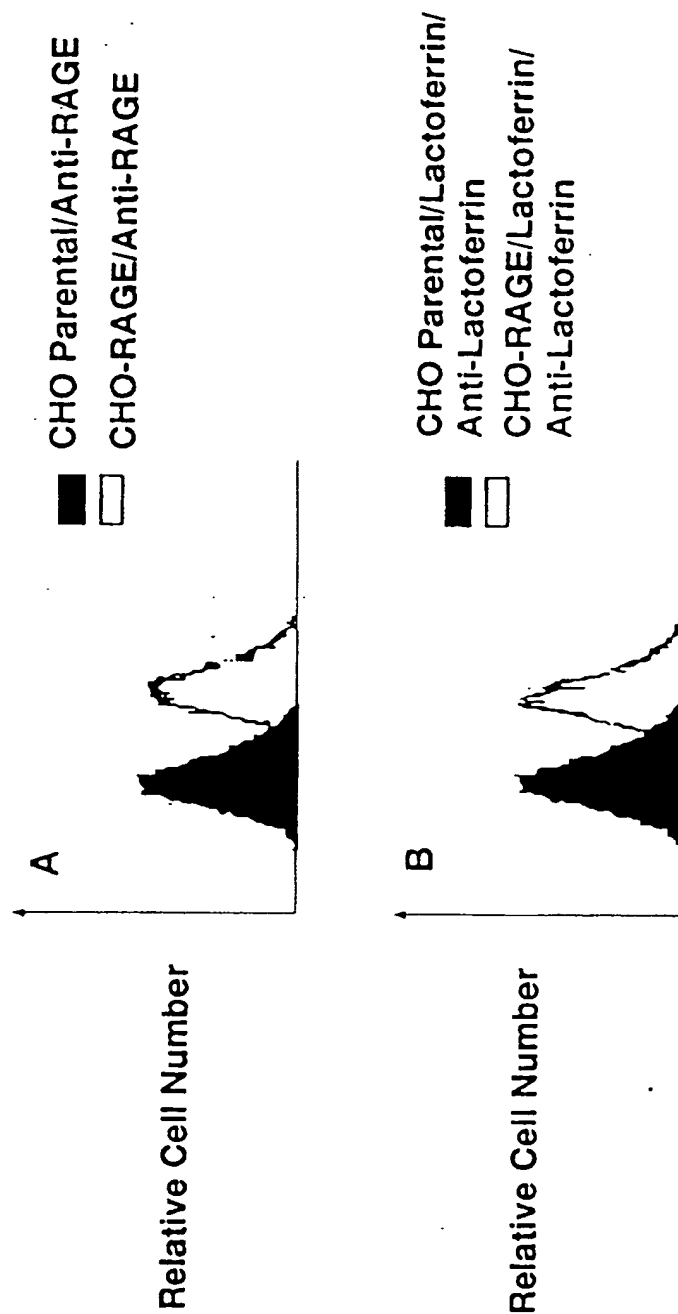


Figure 8

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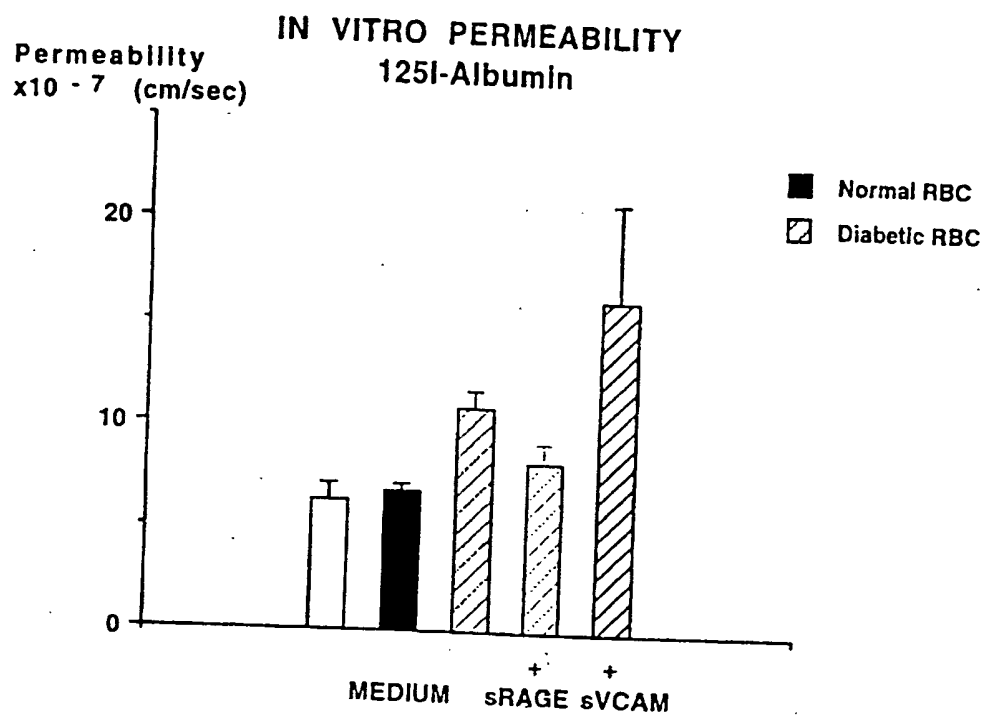


Figure 9A



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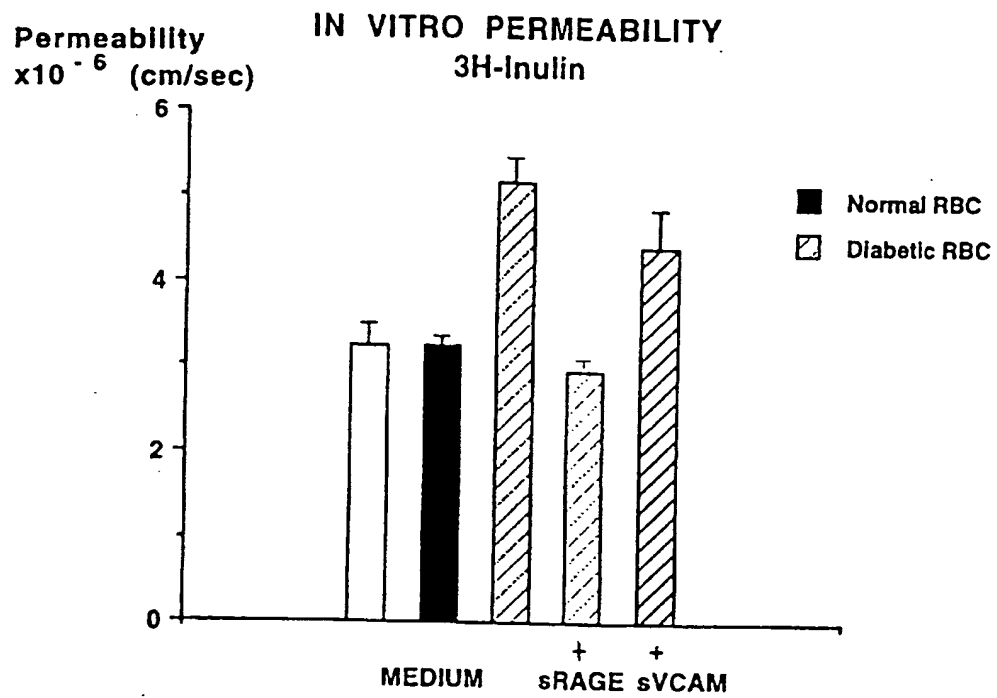


Figure 9B

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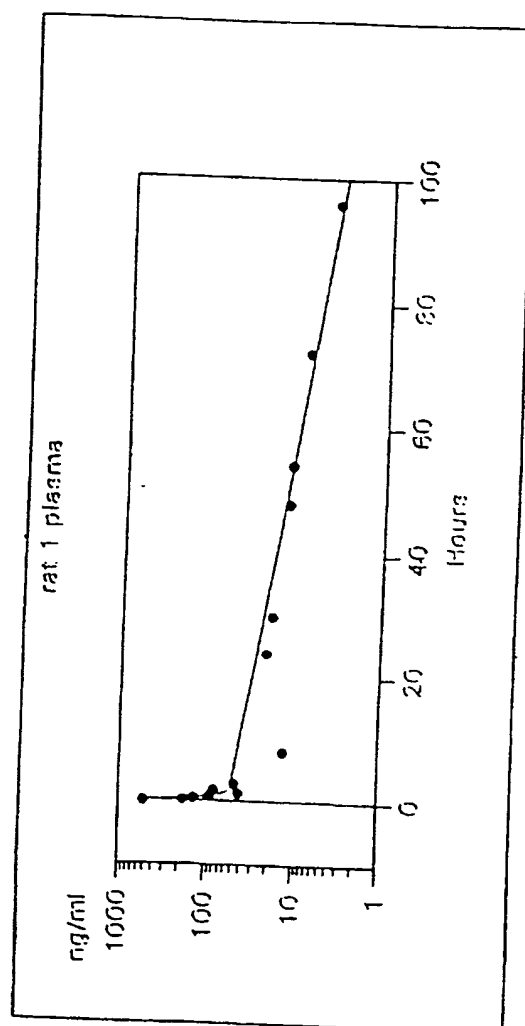


Figure 10

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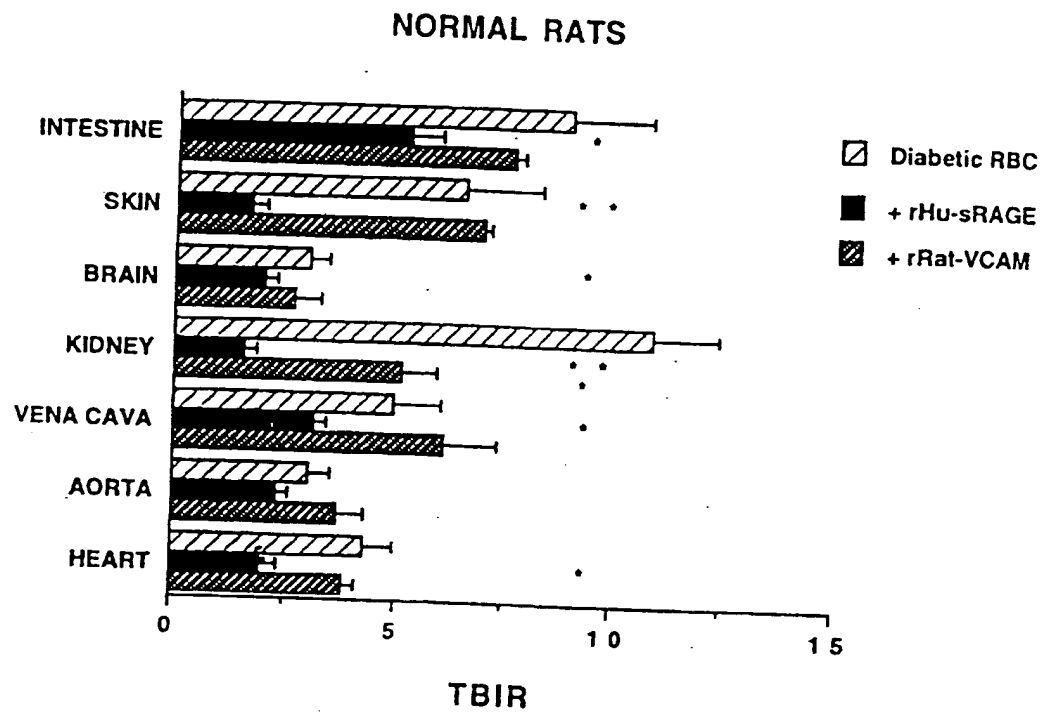


Figure 11A

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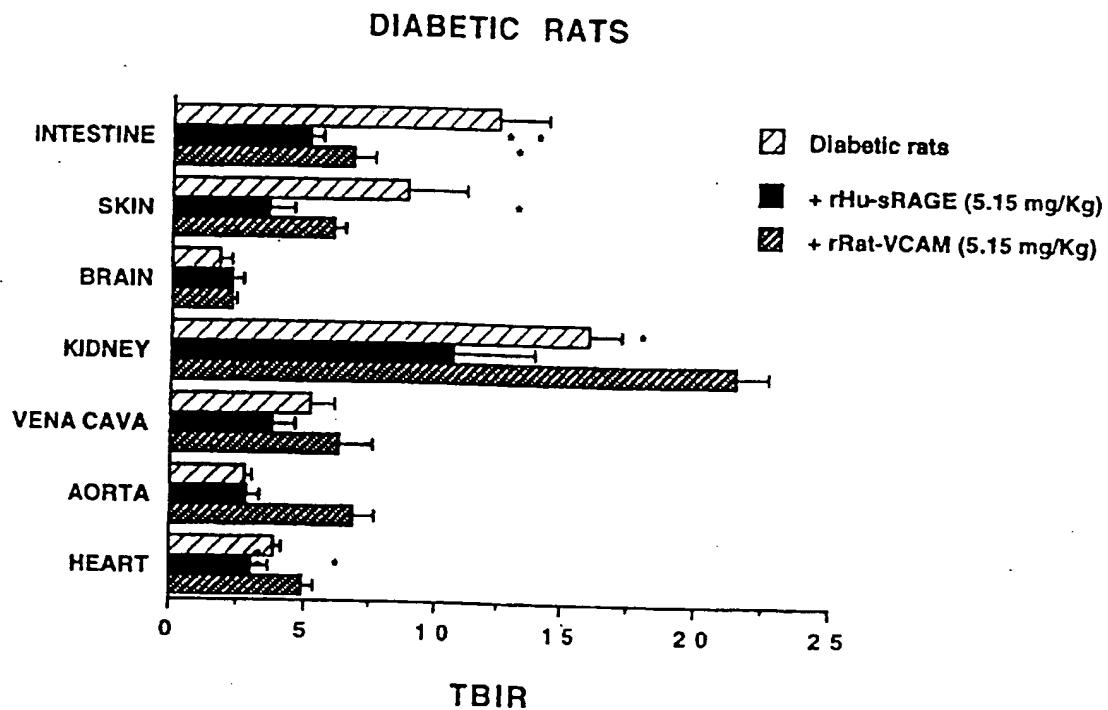
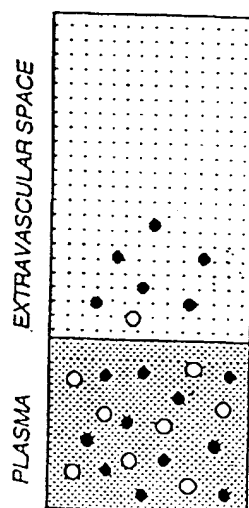


Figure 11B

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# BLOOD - TISSUE ALBUMIN TRANSPORT TRACER UPTAKE METHOD

## TISSUE SAMPLE



- test tracer (  $^{131}\text{I}$ -RSA)  
circulation time = 35 min
- O reference (  $^{125}\text{I}$ -RSA)  
circulation time = 5 min

$$\text{REFERENCE VOLUME} = \frac{\text{TOTAL } ^{125}\text{I COUNTS}}{\text{PLASMA } [^{125}\text{I}]} = \text{TISSUE PLASMA VOLUME}$$

$$\text{TEST TRACER VOLUME} = \frac{\text{TOTAL } ^{131}\text{I COUNTS}}{\text{AVG PLASMA } [^{131}\text{I}]} = \text{PLASMA VOLUME + EXTRAVASCULAR DISTRIBUTION OF TEST TRACER}$$

$$\therefore \frac{\text{TEST TRACER VOLUME} - \text{PLASMA VOLUME}}{30 \text{ min}} = \text{BLOOD-TISSUE ALBUMIN CLEARANCE} \quad (\mu\text{l/g dry wt})/\text{min}$$

Figure 12

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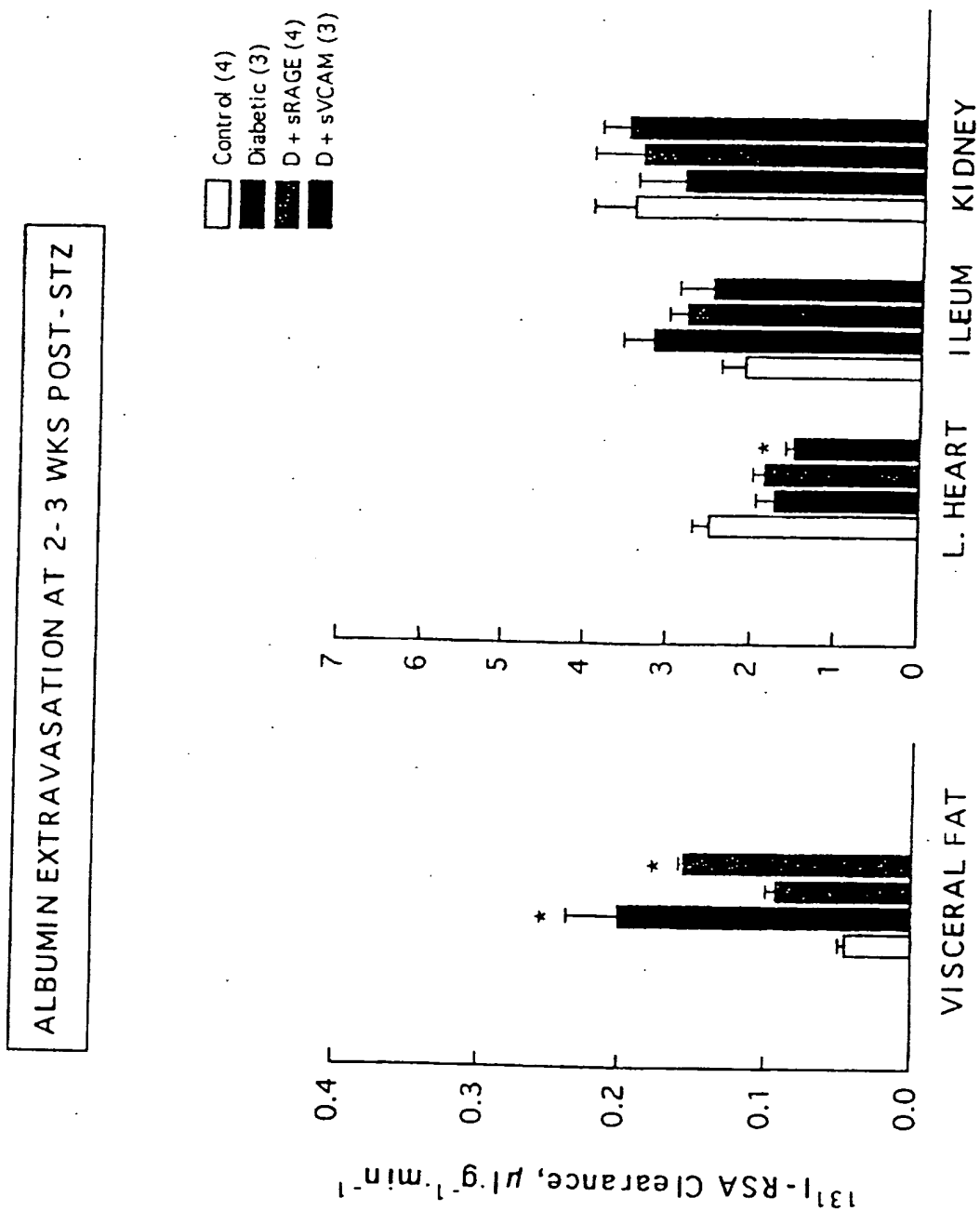


Figure 13A

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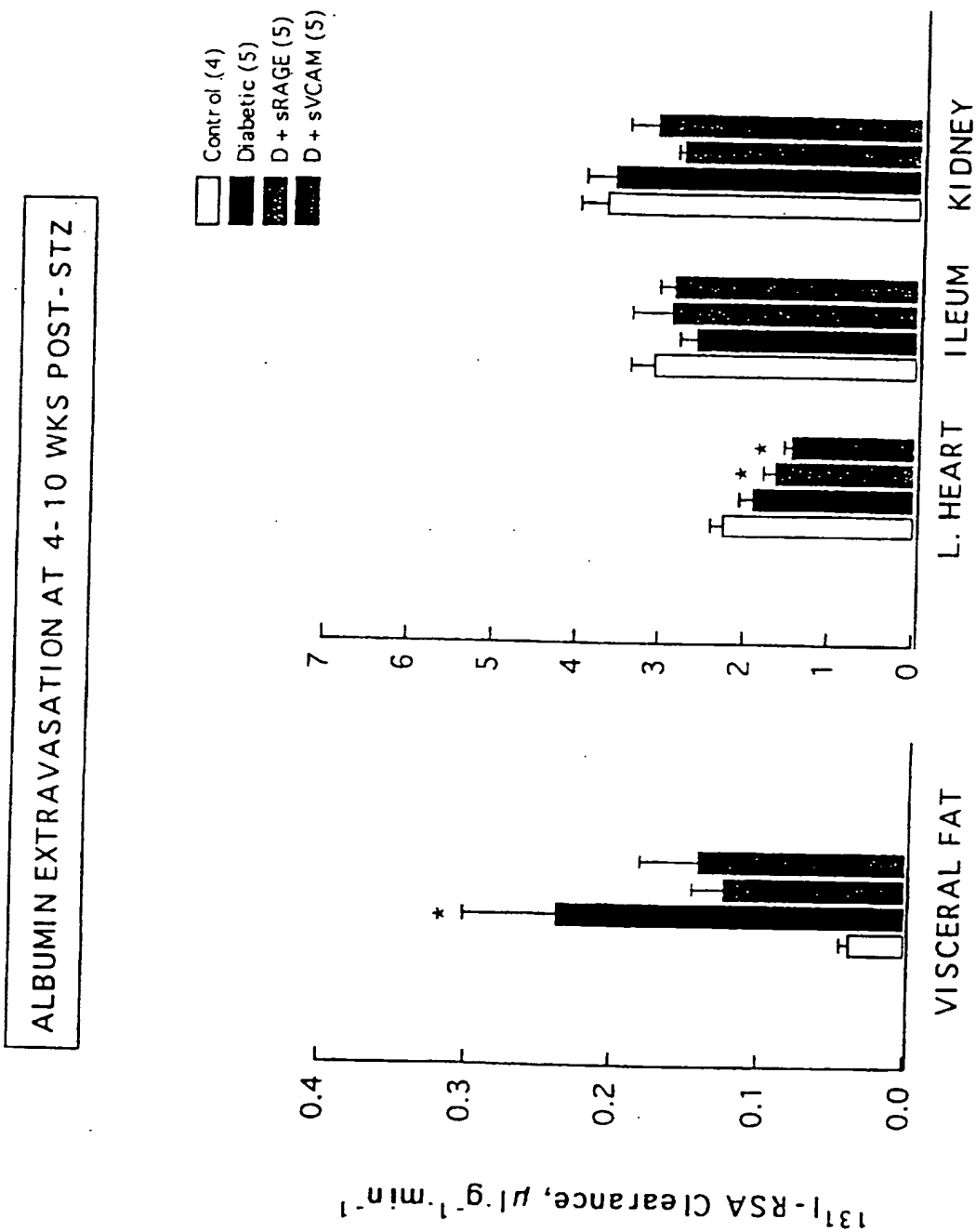


Figure 13B

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ALBUMIN EXTRAVASATION AT 11-20 WKS POST-STZ

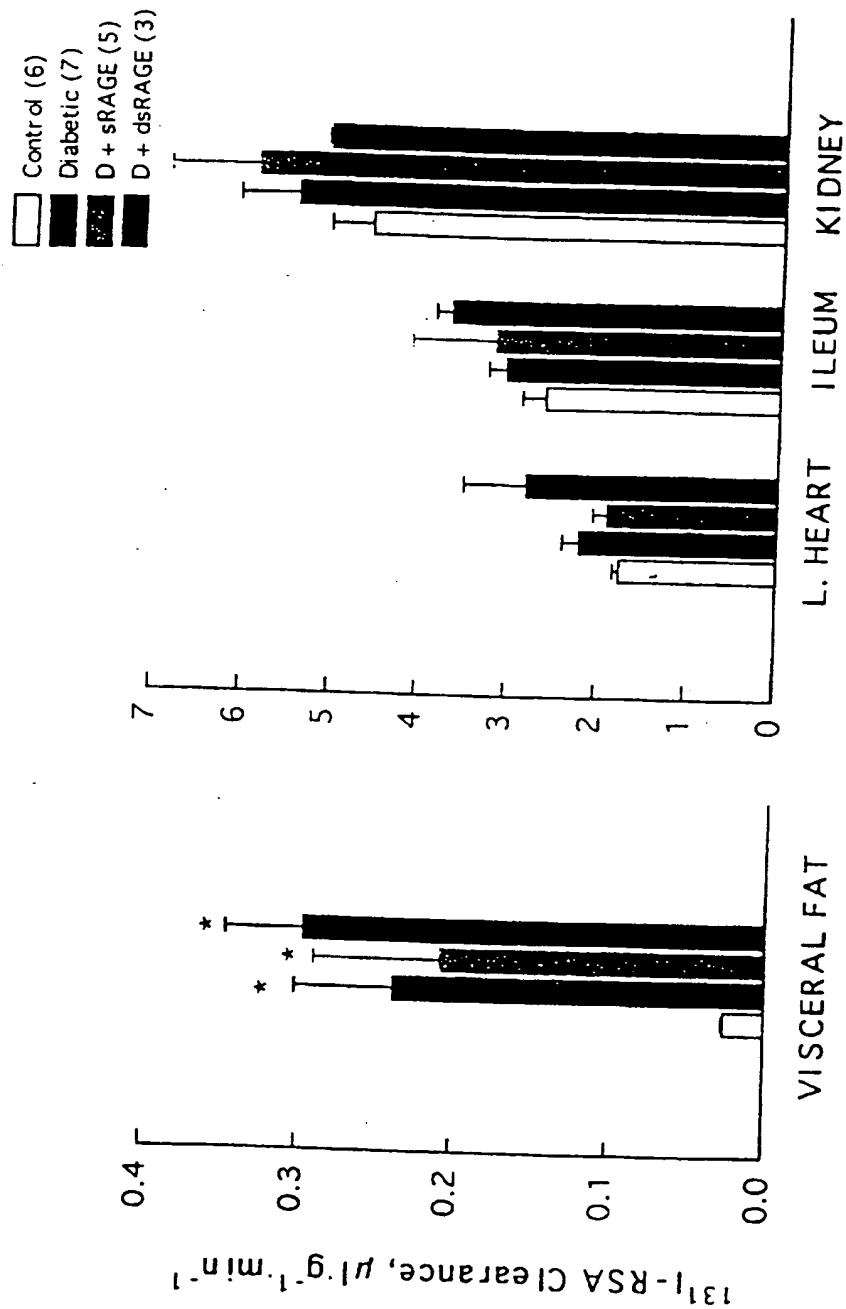


Figure 13C



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EXTRAVASCULAR WATER AT 2-3 WKS POST-STZ

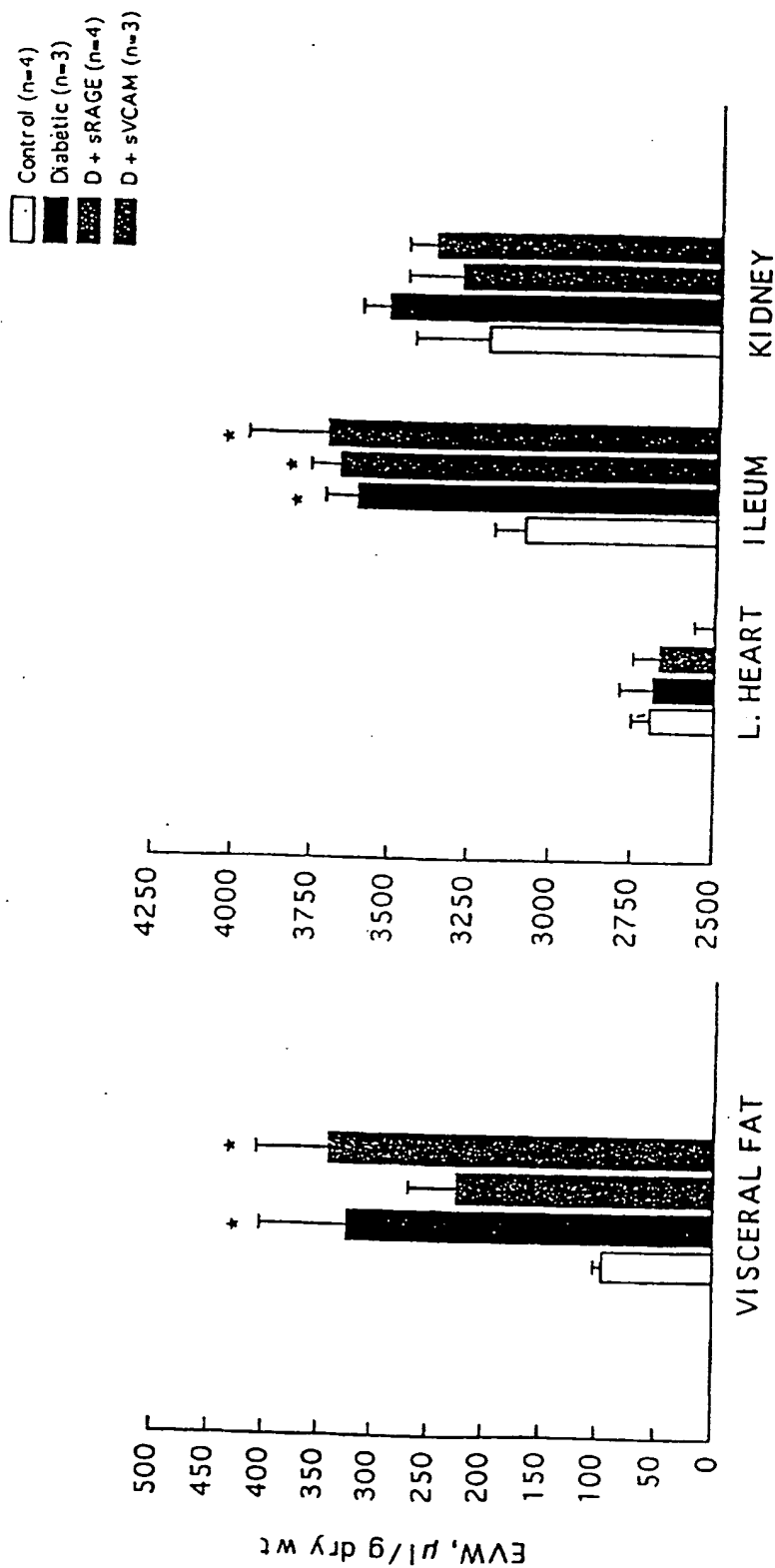


Figure 14A

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EXTRAVASCULAR WATER AT 4-10 WKS POST-STZ

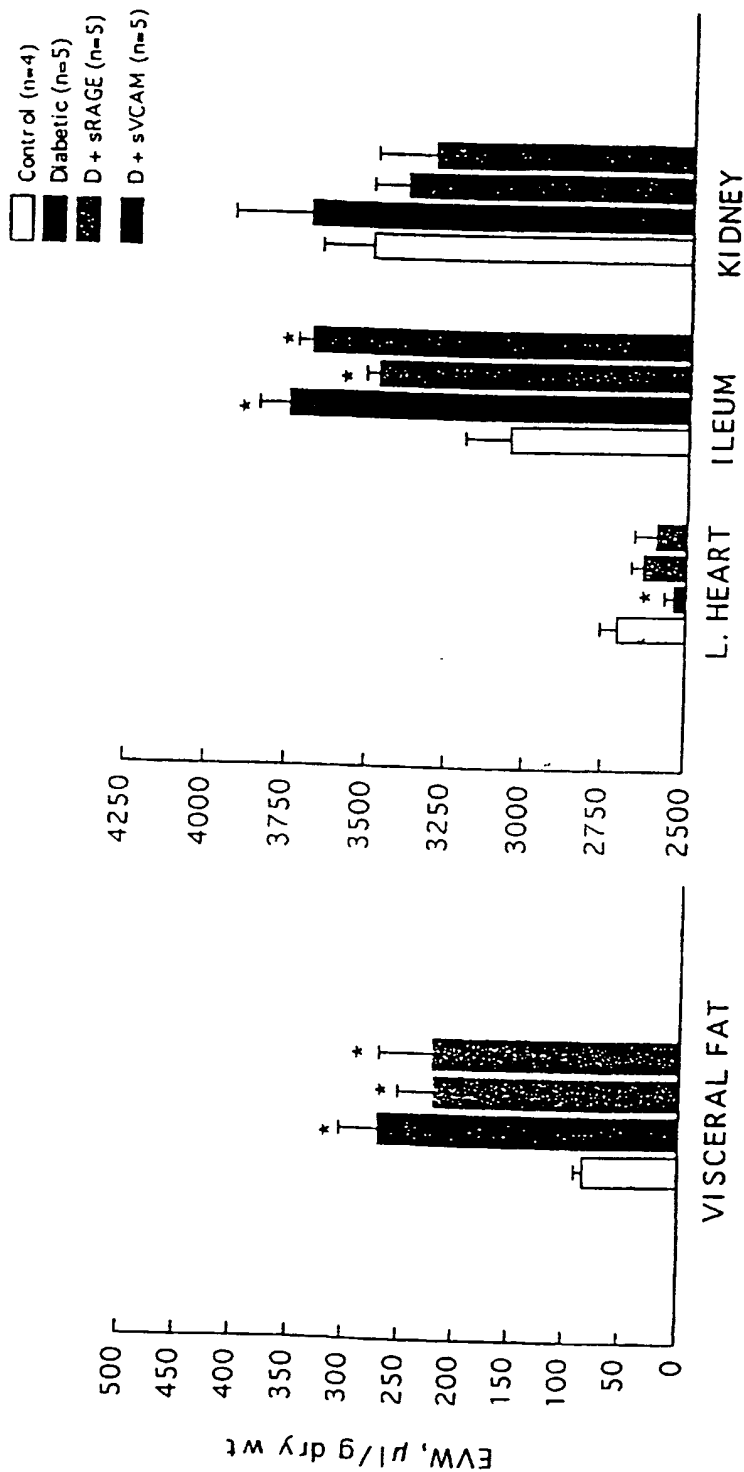


Figure 14B

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EXTRAVASCULAR WATER AT 11-20 WKS POST-STZ

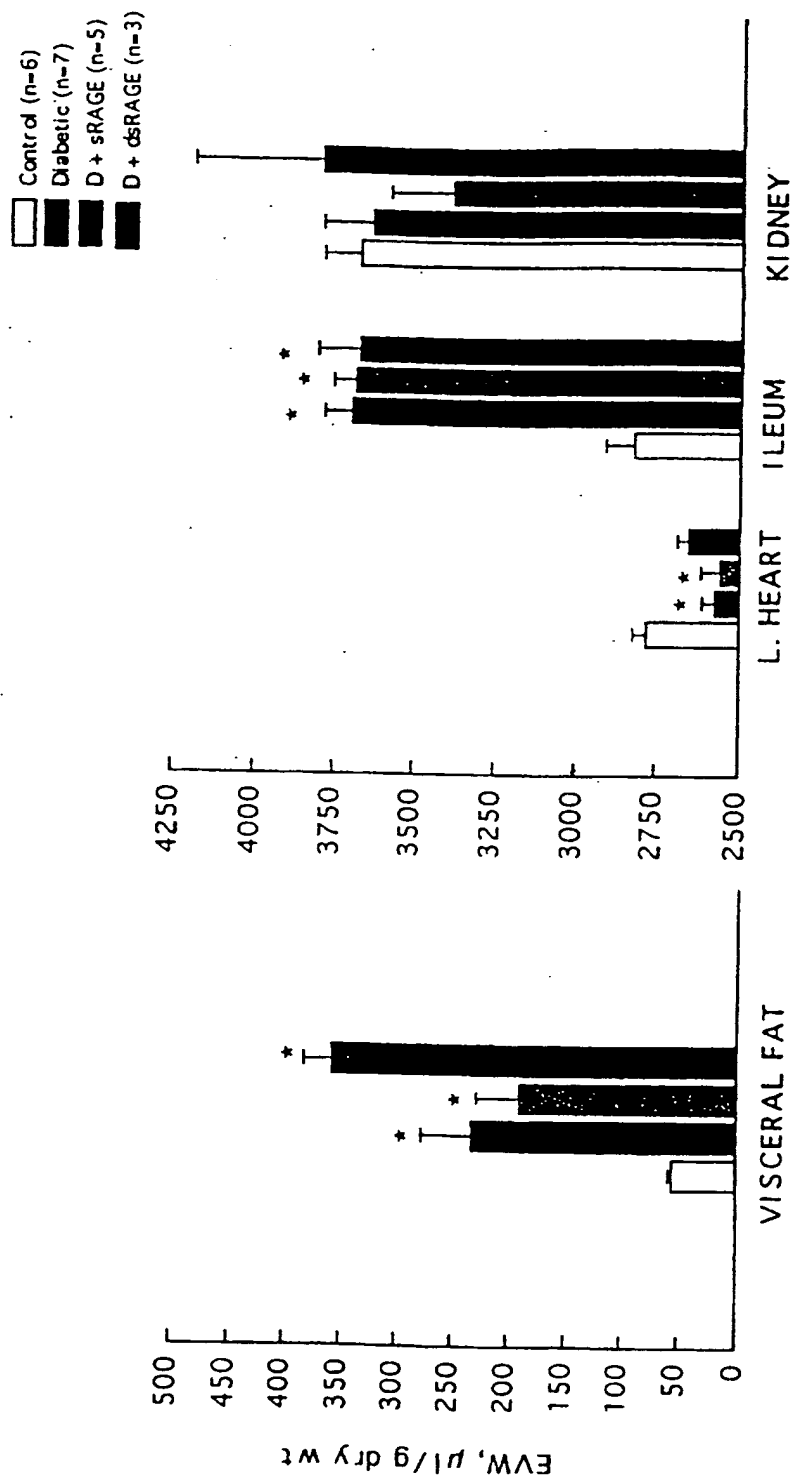


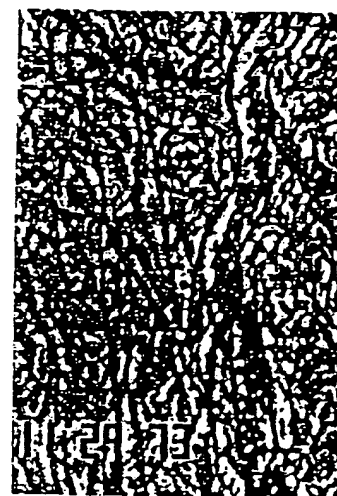
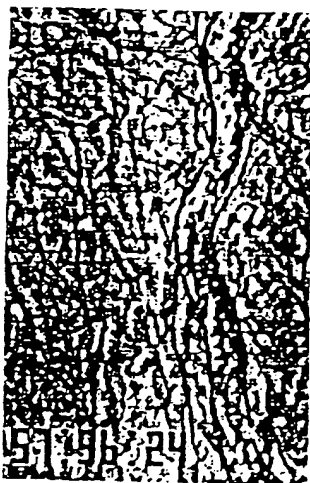
Figure 14C

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## ADHERENCE OF DIABETIC RED CELLS TO VENULES IN SITU



1. Control post-capillary venule perfused with diabetic RBC

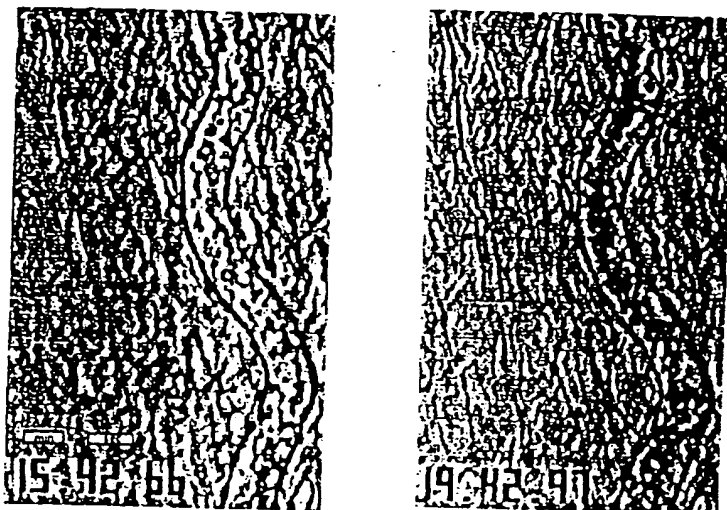


2. Same venule recannulated with Diabetic RBC + sRAGE (incubated 1 Hr)

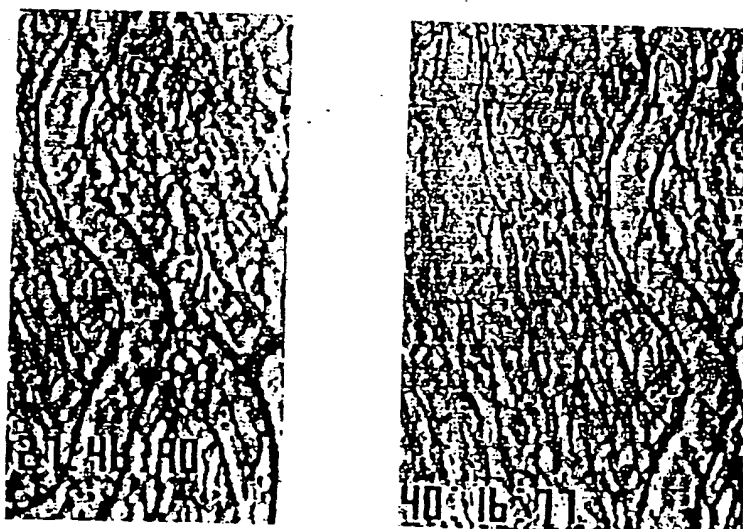
Figure 15A

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ADHERENCE OF DIABETIC RED CELLS TO VENULES IN SITU



1. Control post-capillary venule perfused with diabetic RBC + sRAGE



2. Same venule recannulated with Diabetic RBC - SRAGE

Figure 15B

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 97/01834

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 C12N15/13 C07K16/28 A61K39/395 G01N33/53

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C07K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	THE JOURNAL OF BIOLOGICAL CHEMISTRY, vol. 267, no. 21, 25 July 1992, pages 14998-15004, XP002036214 NEEPER ET AL: "CLONING AND EXPRESSION OF A CELL SURFACE RECEPTOR FOR ADVANCED GLYCOSYLATION END PRODUCTS OF PROTEINS" cited in the application see the whole document ---	1-4,6-27
X	THE JOURNAL OF BIOLOGICAL CHEMISTRY, vol. 269, no. 13, 1 April 1994, pages 9889-9897, XP002036215 YAN ET AL: "ENHANCED CELLULAR OXIDANT STRESS BY THE INTERACTION OF ADVANCED GLYCATION END PRODUCTS WITH THEIR RECEPTORS/BINDING PROTEINS" see the whole document ---	1-4,6-27
	--- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- \*A\* document member of the same patent family

Date of the actual completion of the international search

28 July 1997

Date of mailing of the international search report

07.08.97

Name and mailing address of the ISA

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Fax (+ 31-70) 340-3016

Authorized officer

Sitch, W

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 97/01834

C(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, USA, vol. 91, August 1994, pages 7742-7746, XP002036216 WAUTIER ET AL: "ADVANCED GLYCATION END PRODUCTS (AGES) ON THE SURFACE OF DIABETIC ERYTHROCYTES BIND TO THE VESSEL WALL VIA A SPECIFIC RECEPTOR INDUCING OXIDANT STRESS IN THE VASCULATURE: A LINK BETWEEN SURFACE-ASSOCIATED AGES AND DIABETIC COMPLICATIONS" see the whole document</p> <p>---</p>	1-4,6-27
X	<p>THE JOURNAL OF BIOLOGICAL CHEMISTRY, vol. 270, no. 43, 27 October 1995, pages 25752-25761, XP002036217 HORI ET AL: "THE RECEPTOR FOR ADVANCED GLYCATION END PRODUCTS (RAGE) IS A CELLULAR BINDING SITE FOR AMPHOTERIN. MEDIATION OF NEURITE OUTGROWTH AND CO-EXPRESSION OF RAGE AND AMPHOTERIN IN THE DEVELOPING NERVOUS SYSTEM" see the whole document</p> <p>---</p>	1-4,6-27
X	<p>DATABASE CHEMICAL ABSTRACTS FILE SERVER STN KARLSRUHE ABSTRACT 122:233401, VLASSARA: "AGE-RECEPTORS AND IN VIVO BIOLOGICAL EFFECTS OF AGES" XP002036218 see abstract &amp; SPEC.PUBL.-R.SOC.CHEM., vol. 151, 1994, pages 254-261,</p> <p>---</p>	1-4,6-27
X	<p>DATABASE BIOSIS BIOSCIENCES INFORMATION SERVICE, PHILADELPHIA, PA, US ABSTRACT 94:62056, IMANI ET AL: "ADVANCED GLYCOSYLATION ENDPRODUCT-SPECIFIC RECEPTORS ON HUMAN AND RAT T-LYMPHOCYTES MEDIATE SYNTHESIS OF INTERFERON GAMMA: ROLE IN TISSUE REMODELLING" XP002036219 see abstract &amp; JOURNAL OF EXPERIMENTAL MEDICINE, vol. 178, no. 6, 1993, pages 2165-2172,</p> <p>---</p>	1-4,6-27

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 97/01834

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>DATABASE MEDLINE            FILE SERVER STN KARLSRUHE            ABSTRACT 97197240,            HORI ET AL: "THE RECEPTOR FOR ADVANCED            GLYCATION END-PRODUCTS HAS A CENTRAL ROLE            IN MEDIATING THE EFFECTS OF ADVANCED            GLYCATION END-PRODUCTS ON THE DEVELOPMENT            OF VASCULAR DISEASE IN DIABETES MELLITUS"            XP002036220            see abstract            &amp; NEPHROLOGY, DIALYSIS, TRANSPLANTATION,            vol. 11, no. S5, 1996,            pages 13-16,</p>	1-4,6-27
X	<p>---            WO 93 04086 A (UNIV ROCKEFELLER) 4 March            1993            see page 3, line 33 - page 4, line 17            see page 8, line 12 - page 10, line 30            see page 46, line 17 - line 25            see page 52, line 1 - line 14            -----</p>	1-4,6-27



# INTERNATIONAL SEARCH REPORT

International application No.

PCT/EP 97/01834

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 17-20  
because they relate to subject matter not required to be searched by this Authority, namely:  
Remark: Although claim(s) 17-20  
is(are) directed to a method of treatment of the human/animal  
body, the search has been carried out and based on the alleged  
effects of the compound/composition.
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such  
an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all  
searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment  
of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report  
covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is  
restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 97/01834

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9304086 A	04-03-93	US 5585344 A	17-12-96	
		US 5202424 A	13-04-93	
		AU 2506792 A	16-03-93	
		US 5316754 A	31-05-94	
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Form PCT/ISA/210 (patent family annex) (July 1992)